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"Where σ is stress, *p* is density and V is particle velocity . . ."

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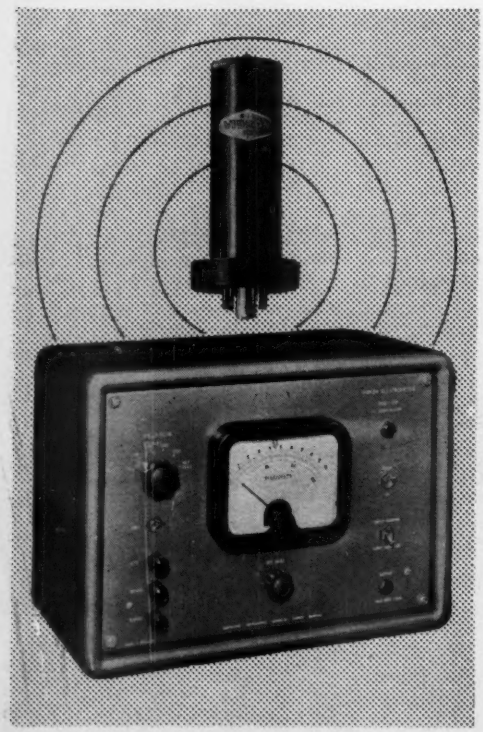

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SCIENCE, BUSINESS AND EDUCATION

TWENTY-SIX years ago, the papers read to the Department of Industrial Co-operation (a group within Section F) at the centenary meeting of the British Association were published under the title "Business and Science". The main emphasis in these papers is on management, but a glance at their titles in the context of automation and other subsequent developments shows the prescience of the organizers of that gathering. Sir Alexander Fleck borrows the title of the volume for his presidential address at the Glasgow meeting of the Association (see p. 573 of this issue of *Nature*). To some it may appear that his address is platitudinous; but the charge is unjustified. Some familiar truths are indeed re-stated, but there are others, notably in regard to the nature of business activity, which badly needed to be re-stated and are more often disregarded than put into effect.

Sir Alexander, however, adds to his title the words "A Balanced Partnership", and in doing so displays the quality that gives his address its distinctive character and value. Disclaiming any intimate acquaintance with the practice of particular disciplines, he speaks, much as the late Lord Stamp spoke at Blackpool, as one who, himself trained as a scientist and understanding the framework within which scientific thought develops, is also familiar with the outlook and problems which confront the business or industrial administrator who is concerned to make generally available the services or goods which scientific and technical knowledge can provide. In that connexion it is pertinent to recall that, when last November the Prime Minister announced his choice of Sir Alexander Fleck to preside over the three committees of inquiry into the accident at Windscale, Mr. Macmillan gave as the decisive reason his belief that in the highly technical aspects of the accident Sir Alexander had sufficient scientific knowledge of a general character.

Whatever so-called platitudes this address may contain, they are re-stated with the clarity to be expected of one whose recognition of the importance of clear exposition and vivid interpretation is well known, and with the balance and perspective which are often derived from the simultaneous study of science and history which once again Sir Alexander advocates in this address. But above all they are emphasized by the wealth of experience and the sound judgment which have frequently marked Sir Alexander as pre-eminently the man to fill some particular post where understanding of both science and public affairs is required.

This note of authority sufficiently refutes any real thought of platitude; but there is a further reason which gives particular interest to a presidential address quite distinct from those of most of his predecessors. In itself, it demonstrates the decisive importance of both a balanced outlook and a balanced education in order to achieve that partnership of science and business which Sir Alexander regards as fundamental, and especially a balanced relation between science and government which is no less essential. As Sir Alexander observes, if science is to further our social evolution, it needs the financial and productive effort of business, while no less fundamentally, the prosperity of Great Britain depends on the technologically sophisticated products of our export trade.

Sir Alexander devotes about half his address to indicating how this balanced partnership between science and business can be achieved; but his suggestions are concentrated mainly on the place of the scientist in the business structure and on the achievement of balance in education. What Sir Alexander says about the functions of the scientist in business indeed leads up to and underlines the necessity for balance in education, for the avoidance of premature specialization, the formation of character and the development of intellect and personality. He recognizes indeed that education must to some extent aim at providing useful members of society, and he does not believe that to do so—even in the universities—is completely contrary to the British tradition of individual liberty. But while in framing our formal education we cannot entirely ignore the requirements of the society in which that educational system exists, he points out that that society will not be tolerable to live in if its members are not permitted to develop their personalities and talents.

This respect for the desires and personality of the individual also pervades Sir Alexander's brief survey of the functions and opportunities of the scientist in business. He stresses the importance of research and illustrates the way it functions, the dependence upon team-work between specialists in varied scientific disciplines, the distinction between research and development and the functions of design and construction. All this is set forth with lucidity and authority; but Sir Alexander is no less emphatic and convincing in showing how the scientific mind has its essential part to play in production and in the commercial departments, as well as at the level of management and higher administration. Moreover, that contribution cannot be rendered without flexibility and adaptability of mind, as well as breadth of experience. While it is to be hoped that due note will be taken in the appropriate quarters of the importance of scientists infiltrating almost the whole business structure, so that at every administrative level there are those competent to assess for themselves technological or scientific advice, it is no less desirable that scientists themselves should appreciate what Sir Alexander says about the way in which they can fit themselves for high responsibility.

The balance we seek must come in large measure, in Sir Alexander's view, from within the individual himself, derived from the education which the

scientist and the non-scientist should receive. Once again he stresses the need for those who study the humanities to have some understanding of the workings of science, and for the scientist to be able to relate his science to its human context both historically and in terms of the present day. Ultimately, it is on this process that Sir Alexander relies to ensure that full use is made of the scientist in business, both by giving his powers full scope and by fitting him for wider responsibilities and more varied duties.

On that note, that a truly balanced partnership of science and business will manifest itself in the growing use of science and its methods in business, and that such a partnership can only come from a balanced education for scientists and business-men alike—with the reminder that the society which such a partnership can help to build will always require courage, integrity and tenacity—Sir Alexander closes. He himself would be the first to disclaim any novelty for his ideas. In one form or another they have been repeatedly urged in the post-war period, though never with greater cogency. We may well be grateful that they have again been set forth so lucidly from the presidential chair of the British Association by one who speaks with the authority and experience which Sir Alexander can command.

Nor need we be pessimistic as to their effect. It is more than twenty years since the late Lord Stamp, also in a presidential address to the British Association, examined the impact of science upon society and, touching on cultural lags in a dynamic society, approached this question of balance at a different angle. Lord Stamp's address displayed the same sense of responsibility on the part of business as does Sir Alexander's, but he said little or nothing about the vital question of education, and his remarks about the scientific worker in a wider field lacked the incisiveness of Sir Alexander's. In the interval, the question of education has come to the front, and there are few things more encouraging than the growing recognition, especially in the past few years, of the vital importance of a balanced education. We have still to reach agreement as to the way or ways in which such an education can be provided, though some notable leads have been given in recent months. Sir Alexander's address will bring a new sense of urgency and inspire the co-operation and understanding that are essential for the sustained effort which he himself recognizes as the true line of advance.

SIR GEOFFREY TAYLOR'S WORK ON THE MECHANICS OF SOLIDS

The Scientific Papers of Sir Geoffrey Ingram Taylor
Edited by Dr. G. K. Batchelor. Vol. 1: Mechanics of Solids. Pp. x+593. (Cambridge: At the University Press, 1958.) 75*s*. net.

IT was an excellent idea to publish in collected form the scientific papers of Sir Geoffrey Taylor, papers which have done so much to establish our modern views on the mechanics of real materials. When Sir Geoffrey began his researches about forty-five years ago the only serious attempt that then existed to understand the mechanical properties of matter in terms of atomic structure was the kinetic theory of gases; and this theory could say scarcely anything about the turbulent motion which is man's oldest and most familiar experience of the mechanics of gases. Practically nothing was understood about solids and liquids. Apart from a few theorems on the elasticity of crystals, both these states of matter were discussed by analogy with hypothetical continuous media which had certain ideal properties. The laws of these media owed nothing to the particulate structure of matter, and the things they predicted were often so different from what occurred in real materials that the subject was no longer regarded as physics but applied mathematics. Even within the framework of these idealized laws, many problems remained unsolved. Turbulent flow, for example, was scarcely less difficult for the theory of ideal liquids than for the kinetic theory of gases. As for calculating the viscosity of water from first principles, or understanding why a piece of copper wire stretches a certain amount and then breaks at a certain stress when pulled at its ends, such things were quite out of question. This part of the subject seemed so unapproachable that at least one distinguished scientist ventured the opinion "ignorabimus" about it.

Although it deals only with solids—the papers on fluids are to appear in three other volumes—this first volume of Sir Geoffrey's papers shows most fascinatingly how the science of the mechanical properties of matter has become transformed over the past forty years and how this transformation has been brought about mainly by these papers themselves. The first three papers, published jointly with A. A. Griffith in 1917–18, describe the famous method for solving problems of torsion in elasticity by the use of soap films, whereas the last paper, which was read in Madrid at a conference in 1955, contrasts plastic slip in body-centred cubic and face-centred cubic crystals, and develops from this contrast a theory of why polycrystalline iron differs from metals such as aluminium and copper in its plastic properties. What a striking development of the subject this represents! Here one is dealing with plastic slip in real crystals, taking full account of the crystal structure and its influence on the slip process, distinguishing between one metal and another, and at the same time taking full account of the polycrystalline structure of the material and the effects of intercrystalline boundaries.

The forty or so papers that have made this possible are all set out in this volume, and they include several that were written originally for Government departments or advisory committees and are published here for the first time. Those familiar with the subject will enjoy being reminded of all the branches that were pioneered by Sir Geoffrey's work; for example, the early papers with Miss Elam that established the crystallographic laws of slip in metals; the papers on stored energy in cold-worked metals; the famous paper written in 1934 on dislocations, the theory of which was foreshadowed in another of Sir Geoffrey's papers published by the Faraday Society in 1928; the paper in 1938 which showed for the first time how to deal mathematically with the plastic deformation of polycrystalline aggregates; the papers on plastic waves and effects of shock loading; and the papers on the laws of plastic deformation under combined stresses. Those new to the subject will find in these

papers an introduction which, for originality, clarity, enjoyment, enthusiasm, and authority, could not be better. The editor of this volume, Dr. G. K. Batchelor, and its sponsors, the Ministry of Supply and Trinity College, Cambridge, are to be congratulated on their valuable enterprise. A. H. COTTRELL

NUCLEAR PHYSICS AND ATOM BOMBS

Brighter Than a Thousand Suns

The Moral and Political History of the Atomic Scientists. By Dr. Robert Jungk. Translated into English by James Cleugh. Pp. 350. (London: Victor Gollancz, Ltd., in association with Rupert Hart-Davis, Ltd., 1958.) 21*s*. net.

DR. ROBERT JUNGK attempts in this book to write "The Moral and Political History of the Atomic Scientists" or "the inside story behind the construction of the atomic and hydrogen bombs". The story is written largely around personalities, including Rutherford, Bohr, Heisenberg, Joliot-Curie, Kapitza, Fermi, Oppenheimer, Szilard and Teller. The author has obtained his knowledge at second hand by diligent inquiry from a galaxy of scientists whose help is acknowledged in the introduction.

The story opens with Rutherford's disintegration of nitrogen by α-particles and rapidly switches to Göttingen to describe the life of the scientific notables of the day—Born, Frank, Klein, Heisenberg and Hilbert, with their numerous visitors, including Bohr, Blackett, Dirac, Oppenheimer and Pauli. It describes the dismissal of the seven Jewish professors from Göttingen, including Max Born and Courant, after Hitler's seizure of power, and follows this with a sympathetic account of Niels Bohr's Institute of Theoretical Physics in Copenhagen, referring to his "Castle of Carlsberg" and an amusing parody of Faust in which Bohr and Pauli were principal characters.

From here the story turns to Cambridge, where a highly inaccurate account of the Cavendish Laboratory is given. The nuclear physicists, including Blackett, Oliphant, Feather and myself, are said to have worked as a kind of "subordinate section" directed by Kapitza. He refers also to Kapitza's "baby giants of high voltage". Nothing could be farther from the truth, for Kapitza took no part in experimental nuclear physics at this time. Kapitza's detention in the U.S.S.R. in 1934 is said to have had "a disruptive effect on the Cavendish as a whole" and "Rutherford's own mighty frame suddenly began to age". This again is more fiction than fact.

The narrative then moves to Rome and Fermi's work on the production of radioactivity by neutrons. The author discusses why fission was not discovered in these experiments, and suggests that physicists did not appreciate that neutrons might be able to penetrate the potential barrier of heavy elements. Since Fermi was producing radioactivity in many heavy elements this is nonsense. What the physicists and chemists failed for so long to realize was that processes other than the emission of protons, α-particles and electrons could take place. There is also an account of supposed friction between Madame Joliot and Madame Meitner resulting from the Solvay Conference of 1933. The discussions are reported verbatim in the Solvay Conference Papers and do not support this. These early chapters do not therefore provide high marks for the author's credibility or scientific knowledge.

After this the story goes on to the discovery of fission and thereafter to the war years and the 'uranium project' in Germany, which was directed entirely to producing a heavy water atomic pile and never to produce an atomic bomb. The narrator gives an account of discussions between Houtermans and Weizäcker in 1941, in which he states that the two agreed that the first and most important task of uranium policy must be to keep departments in the dark about the now imminent feasibility of manufacturing such bombs. The author's general thesis about the German atomic energy project is contrary to the conclusions of Goudsmit in "Alsos".

After this the story moves to the United States, to describe the origin of the atomic project in that country and the development of the Manhattan project, and then devotes two chapters to Oppenheimer's founding of Los Alamos and the development of the atomic bomb.

The author then gives an account of the discussions as to whether and how the atomic bomb should be used and describes the labours of the United States 'Interim Committee' which had to advise the President on this question. The Interim Committee had a scientific panel consisting of Oppenheimer, Fermi, A. H. Compton and E. O. Lawrence. These discussions have been described in much more detail and from first-hand knowledge in A. H. Compton's book "An Atomic Quest". Opinion on the scientific panel was divided as to whether and how the bomb should be used. There were similarly divided views among the staffs of the Chicago laboratories. However, the doubts of the scientists produced little effect, and Mr. Stimson, Secretary for War, has given his own account of the reasons, based on potential loss of American lives, which led him to advise that the bomb should be used. Dr. Jungk records General Grove's view that President Truman did "not so much say yes as not say no".

The story moves on to the years of McCarthyism in the United States and the investigation of Robert Oppenheimer. It retells the now familiar story of the debates as to whether the United States should develop the hydrogen bomb.

One chapter of the book is devoted to the Fuchs case. The author makes the remarkable and ridiculous suggestion that the Russians might have denounced Fuchs to the British Intelligence Service to upset Anglo-American relations.

The author concludes that these events have forced physicists to leave their 'ivory towers' and to be made aware of their responsibilities to the world.

The book as a whole is interesting, but it cannot be considered as an accurate historical account of these developments. JOHN COCKCROFT

CO-OPERATIVE PHENOMENA

Changes of State

A Mathematical-Physical Assessment. By H. N. V. Temperley. Pp. xi+324. (London: Cleaver-Hume Press, Ltd., 1956.) 50*s*. net.

THE term 'changes of state' would usually be taken to imply primarily the processes of fusion and evaporation for which, typically, the transition temperature is sharply defined. There are, however, many other changes of state which proceed more

gradually as the temperature changes; and a 'critical temperature' may be associated not with a latent heat but with, for example, a discontinuity in the specific heat. "Until comparatively recent times", the author says, "the underlying similarities of all changes of state have not been realised". In this volume, he directs attention to the formal similarities, and discusses fully the individual peculiarities. After a short historical introduction, he classifies the various types of change from a thermodynamic point of view, gives a general account of basic theoretical considerations, and then surveys in detail the main fields in which changes of state are involved. Successive chapters deal with evaporation, fusion, solutions and order–disorder phenomena, ferromagnetism and antiferromagnetism, ferroelectricity, superconductivity, and the transition of liquid helium.

The author deals mainly with the development of interpretative descriptions of collective behaviour, using justifiable or plausible 'models', that is, essentially, assumed types of interaction between atoms or molecules. He is not usually concerned with precise comparisons with experiment, for the models which can be fully worked out are so idealized that, he says, "the emergence of a theoretical curve passing through the experimental points is not *quite* the occasion for rejoicing that it is in other branches of physics". The book is thus essentially theoretical. It is not heavily mathematical in form, except for occasional outbursts, but a clear understanding of the often complex mathematics involved underlies many of the accounts given in words of the theoretical treatments.

Only a small part of the book deals directly with changes of state, either generally or specifically. Indeed, once an atomic and statistical mechanical treatment is embarked upon, the theory of changes of state cannot be isolated from the theory of the characteristics of the 'phases' between which transitions occur. The main bulk of the book consists of concentrated surveys of some of the most difficult, complex, and controversial problems of theoretical physics arising in the treatment of such co-operative phenomena as those of ferromagnetism and superconductivity.

It is impossible in a short review to do justice to the author's vast range of reading, to his penetrating critical powers, and to the care he has taken in incorporating in a personal assessment a balanced survey of the complementary, or sometimes contradictory, theoretical treatments which have been given of the various phenomena. There are few readers who will not find on almost every page some novel and thought-provoking comment or suggestion.

In spite of the author's own clear-headedness, and the lucidity of his exposition of so many difficult pieces of theory, the book makes very formidable demands on the reader. Most of the chapters are in effect concentrated monographs, but they are not sufficiently independent for separate reading. For a proper appreciation of one of these chapters the reader must have in mind not only the opening chapters of the book but also sections embedded in other earlier chapters and often in later ones, too. Above all, however, bearing in mind that this is a book intended "to help actual and potential research workers to 'find their way around' this fascinating but complicated field", the main issues tend to be confused by the packing in of details which could be fitly accommodated only in specialized treatises of more restricted range.

It may be that the book has just grown from a consideration of changes of state, but after the event a more informative title might have been devised, perhaps including the words 'co-operative phenomena'. The field is almost coterminous with that of the physics of matter, and is of immense importance. There is no other single account of the theoretical aspects as comprehensive as that given here. The journey through the book is difficult, but it is to be hoped that many will face its ardours; they will be richly rewarded.

E. C. Stoner

RUSSIAN ASTROPHYSICS

Theoretical Astrophysics

Edited by V. A. Ambartsumyan. Translated from the Russian by J. B. Sykes. Pp. xii+645. (London: Pergamon Press, Ltd., 1958.) 135*s*.

THIS book is a translation of a well-known Russian text-book, a co-operative work by five authors, E. R. Mustel, V. V. Sobolev, A. B. Severnyi, S. B. Pikel'ner, and V. A. Ambartsumyan, who also acted as general editor. The Russian version appeared in 1952 and few corrections or additions have been made for this English edition, although an editorial preface rather ruefully comments on the difficulties created by the very rapid development of astrophysics in recent years.

The reader will find a thorough treatment of those parts of the subject which were the centre of attention between the Wars, but little on other branches which have grown so spectacularly during the past ten or fifteen years. The development of new photometric methods and of radio astronomy, and the application of electronic computers to the internal structure of stars, have led recently to a concentration on problems of galactic structure, of interstellar matter, of star populations and stellar evolution, and have also revived interest in the older techniques of astrometry, radial velocities, etc. Little of these subjects appears here. This is understandable enough and scarcely a cause for complaint, but I would have preferred the book to have had a less general title, giving a more precise indication of the contents. A comprehensive account of theoretical astrophysics is to-day beyond the powers of one author and beyond the capacity of any ordinary text-book, while rapid growth and change make early obsolescence almost inevitable. These are very real and serious difficulties, in whatever language the book may be written.

Sixteen chapters, about half the book, are devoted to the problems of stellar atmospheres, especially the theory of radiative equilibrium, the formation of continuous spectra, Fraunhofer lines, etc. There are six informative chapters on the outer layers of the Sun, including a welcome introduction to the electrodynamic problems which are to-day of such great importance. There are three chapters on planetary nebulæ, two on novæ, and two on stars with bright-line spectra. There are three brief chapters dealing with the internal constitution of stars, confined mainly to the earlier, classical theory. There are also two chapters on the scattering of light in planetary atmospheres and two on interstellar matter.

The book is slightly more elementary than Unsöld's "Theorie der Sternatmosphären". It is a welcome addition to the comparatively few general texts of

solid worth which are now available, and Western readers will find it interesting, too, as an indication of the method of approach adopted for Russian students. Although there are differences of detail, on the whole the treatment is very similar to what would be expected in any good work from Western Europe or the United States. There is a natural tendency to refer to Russian authors in preference to others. In some ways this is a healthy check to Western complacency, but there are some slightly surprising omissions. For example, Hertzsprung does not appear in the index and the cinematography of prominences is discussed without Lyot.

The translation appears to be good and there are few misprints. R. O. REDMAN

ADVANCE OF CHEMICAL TECHNOLOGY

Encyclopedia of Chemical Technology

Edited by Raymond E. Kirk and Donald F. Othmer. First Supplement Volume. Pp. xvii+974. (New York: Interscience Encyclopedia, Inc., 1957. Distributed by Interscience Publishers, Inc.; London: Interscience Publishers, Ltd.) 25 dollars.

IT is more than ten years since the first volume of Kirk and Othmer's "Encyclopedia of Chemical Technology" appeared. Volume 15, which appeared in 1956, brought the alphabet to its end. That volume was reviewed in *Nature* (179, 983, 1957). I expressed satisfaction then that it had been decided to issue a supplementary volume, because an encyclopædia 'however beautiful is ephemeral', unless it can be maintained up to date by some means or other. The purpose of this Supplementary Volume of 974 pages is to bring the Encyclopedia up to date. As pointed out in the foreword, obsolescence is most uneven. Some of the articles in the earlier volumes needed to be brought up to date by alluding to minor improvements in production methods or by providing more up-to-date statistics, but in other articles changes of method may have been so great that considerable revision was indicated. In preparing the Supplementary Volume, the principle adopted has been to describe fully those bigger changes, rather than to make minor additions to the many different articles. Some articles have been added on subjects which were not treated in detail or not at all in the original volume; for example, fluidization and automation.

There are fifty-one articles in the Supplementary Volume, arranged alphabetically. Cross references are made to the original volumes as well as to this one. The index of 43 pages covers the Supplementary Volume alone, and should be consulted together with the very complete index to the original fifteen volumes which formed the greater part of Volume 15.

It is noticed that this new volume is called the First Supplement Volume, and it is well that the publishers seem to be allowing for the future and that further volumes may be expected which will maintain the current utility of the Encyclopedia. Many of the separate articles state at the outset the reasons which have led to their inclusion in the Volume and their relation to former articles in the Encyclopedia and some of the articles give at the end, in a few sentences, the main conclusions and expectation of further progress. This procedure is helpful to the user of this or subsequent supplementary volumes of the Encyclopedia.

The original purpose of Kirk and Othmer's Encyclopedia was to produce a "comprehensive treatment of the American Chemical Industry". The joint authors were successful. Raymond E. Kirk, the senior editor, died after a short illness early in 1957; he lived to see the completion of his great work. The Supplementary Volume opens with a tribute to his memory by his collaborator, Donald F. Othmer.

Glancing through the volume, the first article deals with "Acrolein" and its derivatives, in which the condensation products leading to new polymers are described. "Adhesives" provides the next subject, dealt with in a general way showing the advances made since the preparation of the article in the first volume, particularly in metal-bonding. An interesting article follows on "Algal Culture". Utilization efficiency in growing *Chlorella* is only between 2 to 8 per cent, because of the low light-saturation point. Yields of 20–40 tons an acre a year could be reasonably expected on the basis of the present technology, but there are difficulties attending most of the schemes which have been tried. The articles on "Computers", describing and listing their various types, give a great amount of assistance in the choice of suitable equipment for the study of problems in chemical engineering. "Cyanoethylation", in which the proprionitrile group is involved, forms the subject of the next article, which discusses the recent important development of cyanoethylated cotton, along with polyacrylonitrile fibres. There is considerable reference to "Detergents" in the Encyclopedia, and the new section on this subject brings information up to date. There is no reference in this article to the difficulty of effluent treatment caused by the use of detergents. "Emulsion paints" are referred to as a major development in the paint industry. The binder in water paints is glue or casein, which is made soluble in the water; in emulsion paints, it is insoluble and dispersed in very fine droplets.

"Industrial Enzymes", like papain, are used for chill-proofing of beer, for making meat more tender and for pharmaceutical purposes. 'Pectic' enzymes are used widely in the fruit juice industry. A table is given of industrial and food enzyme preparations on p. 309. "Epoxy resins", derived from epichlorohydrin, have found in recent years many applications as durable crosslinked polymers, used for protective coatings, finishes, metal-to-metal adhesives and structural materials.

Modern methods of "Extraction" as a chemical engineering unit operation are considered in a special article—an unusual example is cited, namely the extraction of fission products of spent nuclear reactor fuel by using molten silver, cerium or lanthanum as selected solvents. "Fluidisation" is one of the chief articles and it is a particularly useful addition to the Encyclopedia. On p. 399 is a diagram representing the results of a number of investigations on heat transfer between fluid beds and tube walls.

The supplementary article on "Hydrocarbon Oxidation" deals with vapour phase oxidation of the lower saturated aliphatic hydrocarbons and outlines, in not too dogmatic a manner, the theory of the chain reactions which can take place. In practice, formaldehyde, methanol, acetaldehyde and acetone are the main commercial products in the oxidation of propane and butane, which is carried out at 100–300 p.s.i.g., sometimes using oxygenated air. "Ion Exchange Resins" are becoming applied for many different purposes. The article refers to water treat-

ment, to recovery of uranium from low-grade ores, to recovery of gold and other metals from cyanide leach, and to processing various pharmaceutical products.

The article on "Peracetic Acid" is excellent. Not many years back, peracetic acid was just a dangerous substance; now, though still unstable when pure, it has become (in solvents or formed *in situ*) an important oxidizing agent for epoxidation of natural oils and their derivatives, and a number of other uses. An article on "Photovoltaic Solar Converters" describes the advances made in photovoltaic cells for the direct conversion of the energy of light to electrical energy, using silicon or cadmium sulphide; other substances, such as gallium arsenide, indium phosphide or cadmium telluride, should be effective.

Polymerization of pure isoprene in the presence of a lithium metal catalyst produces a polymer with structure substantially identical with that of natural rubber. This and other developments in artificial rubber production are presented in the article on "Rubber". "Sorbic acid", a fungistatic agent for foods, has an article to itself, in which methods of production and other uses are described. "Steroids with Corticle Hormone Activity", describing the constitution and production of cortisone and derivatives, provides a valuable review and literature summary, including the cortexone derivative.

This Supplementary Volume contains articles of great current interest which illustrate the remarkable rate of progress of technology.

An encyclopædia is not only valuable for reference and for obtaining knowledge about some special subject, but, like a library, it is pleasant to browse within it, for browsing as well as study often leads to new ideas. This supplementary volume of "Kirk and Othmer" maintains the excellent standard of presentation of the main series of volumes and is an essential addition to the set. A. C. Egerton

EMULSIONS

Emulsions

Theory and Practice. By Paul Becher. (American Chemical Society Monograph Series, No. 135.) Pp. ix+382. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957.) 100*s*.

ONE of the most complex of the systems dealt with in colloid science is that of the emulsions. This is in no small measure due to the fact that they are essentially metastable and in disequilibrium. Dr. Becher quite rightly introduces the subject by giving a brief review of the properties of interfaces and the characteristics of surface activity. In this section the author covers a lot of ground; the discussions on solubilization and on micelle structures are particularly welcome, although the treatment of Gibbs's fundamental equation and its experimental verification might have been dealt with in greater detail, especially in its applicability to micelle-forming electrolytes.

The general physical properties of emulsions are next described before attempting to inquire into the theoretical basis for the apparent stability of such systems as well as the cause of phase inversion. These chapters are excellent in that they emphasize the importance of the interfacial phase in acting as a barrier to the coalescence of liquid drops when brought in contact with one another. Not only must the electrostatic component of the repulsive forces which is approximately proportional to ζ^2, where ζ is the electrokinetic potential, as well as the London, or van der Waals, forces, be considered, but also there is increasing evidence that in the aqueous phase at least the water in close proximity to the interphase has become more ice-like under the influence of the potential gradient existing there, and that the breaking of this ice-like layer in the act of coalescence is a factor that cannot be left out in any computation.

The author rightly points out that the phenomenon of coalescence is an important initial step in both phase inversion and in creaming, where the emulsion separates into two phases, one rich and one poor, in the disperse phase, and the views of Cockbain and of Schulman are clearly presented.

The next two chapters are devoted to a classification of the different types of emulsifying agents and to the various techniques which have been developed for the preparation of emulsions.

The variety of surface-active agents employed for emulsion formation is now extremely extensive. In general, the chemical constitution of such amphipathic substances effects a nice balance between the polar and non-polar portions of the molecule which may be positively, negatively or zero charged. Some discussion on this balance would not have been out of place in this section; for example, a consideration of the ratio of the number of ethylene oxide groups to methylene groups required for a good aliphatic non-ionic detergent. There are two appendixes, one on testing and the other on commercial emulsifying agents.

This is a well-written book, concise in the American style, and the theoretical treatments, where developed, are integrated more closely in the corpus of the volume than is usual in such books. There are few obvious misprints. The format and printing are well up to the standard that we have come to expect of the American Chemical Society Monographs.

Eric K. Rideal

CHEMISTRY OF PLANTS

The Chemistry of Plants

By Prof. Erston V. Miller. Pp. vii+174. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957.) 38*s*. net.

THE principal function of a book on the chemistry of plants is to provide a source of information on the composition of plant tissues and the chemical properties of their major constituents. For the majority of readers, however, such a book would be made more interesting by some discussion of the metabolic relationships of these constituents. In his preface Prof. Miller makes it clear that he does not embrace this latter view and has specifically avoided encroaching on the domain of the plant physiologist.

In fact, the author has not been entirely successful in this and does offer a certain amount of biochemical information, but in quality and amount this is insufficient to redeem the failings of the book as a source of factual information. The author describes himself as "a mere compiler", but in this book he has rather been a collector of the compilations of others. All the tables, except one, are borrowed from

other texts, and in most cases this transfer has reduced their value in that they were not specifically designed for their present context. This has the effect of making the presentation scrappy and the density of information variable and in many places very low. For example, there are given very few quantitative data on the composition of plant tissues and no information on the composition of plant proteins, though both types of data are readily available.

In view of this latter criticism, one might hope that the qualitative data be satisfactorily presented, but unfortunately, this is not the case, as its chemical content is particularly open to criticism. Many substances are mentioned without any indication of their structure being given, other substances of quite elementary importance, such as the unsaturated fatty acids, are inadequately described and some of the information given is quite inaccurate. Isocitric acid is not "the D-isomer of citric acid", hæmocyanin is not, so far as we know, closely related to chlorophyll, and phosphorylases are not to be confused with phosphorylating enzymes. These are just a small sample of the many errors which suggest that the author would be more at home in some other field than the chemical one. Finally, the price is rather high for a book of this size and the text would have to be very greatly improved to justify it.

G. Leaf

CELLULAR BIOLOGY

Les Facteurs de la Croissance Cellulaire

Activation et Inhibition. Publiés sous la direction de Prof. J. André Thomas. (Exposés Actuels de Biologie Cellulaire : 2è série, 1956.) Pp. xii+428+3 planches. (Paris : Masson et Cie., 1956.) 4,000 francs.

A GREAT many books and reviews on the biology of the cell have been produced in recent years, and since the War many new techniques have been applied to this field of research with startling success. Here is yet another review, and although many of the topics dealt with have been more widely surveyed in recent years, often by the same authors, this new collection of articles is nevertheless valuable. With ten authors involved in the production of nine chapters there is inevitably some unevenness in quality. On one hand, some authors have notably failed to include references to all the major work in their field, while on the other an outstanding contribution with a most comprehensive bibliography is that of Chouard and Thimann, who discuss "Les facteurs de la croissance cellulaire végétale".

The reviews included range from the synthesis of proteins through growth in animal and plant cells, growth and differentiation in embryos, the inhibition of mitotic activity, wounding and grafting, to a final review of cancerous growth. Brachet's paper, entitled "Les facteurs d'activation et d'inhibition de la synthèse des protèines", forms an excellent introduction to this subject, and could be read with great advantage by final-year honours students. This can also be said of the chapter by Chouard and Thimann mentioned above. The other contributions are less likely to have a general appeal. In particular, it is remarkable that in a book of this nature there should be no chapter dealing with the great advances which have recently been made in our understanding of the normal physiology of cell division. Instead there are two chapters on "Les facteurs de la mito-inhibition" (Deysson and Dustin), and one on "Les facteurs de la cytonarcose" (Gavaudan), and, although all are interesting, they deal primarily with the toxicology and pharmacology of mitosis.

The final two chapters, on wounding and grafting (May) and on cancer (Oberling), are both interesting, but they are too brief to be of any great value. Indeed the whole book is of an introductory nature, and, apart from the serious omission mentioned above and the pharmacological over-emphasis, its greatest value will be to provide an outsider with some knowledge of modern research work on cellular biology.

W. S. Bullough

A FARMER'S GUIDE TO ANIMAL DISEASES

Veterinary Guide for Farmers

By G. W. Stamm. Edited by Dallas S. Burch. Third edition. Pp. 384. (Chicago, Ill. : Windsor Press, 1957.) 3.95 dollars.

ANIMAL diseases are of great importance to all farmers, for upon their incidence can depend the success or failure of the enterprise. A reduction in the losses caused by animal diseases would greatly benefit the farming community, and the aim of this book is to assist farmers to accomplish this by providing them with information on the diseases which can affect their stock.

The book has been written clearly and concisely, and much technical veterinary knowledge has been simplified and expressed in a manner which can be understood by practical farmers. The book is well produced and excellent photographs and informative diagrams make the author's meaning clear. As the book was written for American farmers it deals with poisonous plants, parasites and diseases which are unknown in the British Isles, and advises the use of drugs, such as antibiotics, which cannot be purchased by farmers in these islands. Also, in dealing with some diseases, no mention is made of prophylactic preparations which British farmers are using extensively. However, providing the reader has the knowledge to appreciate which sections are applicable to his particular conditions, he can obtain information about the diseases which can affect his stock, and the measures which can be adopted to prevent their spread.

This book, however, aims at taking the farmer further than the elementary principles of first aid and the important aspects of disease prevention, and provides information which will enable him to diagnose and treat disease. Skill in diagnosis is an art which can only be acquired by long experience, and text-book knowledge can, in certain cases, increase losses by leading to an inaccurate diagnosis and faulty treatment. An additional point is that veterinary surgeons are relying increasingly on diagnostic aids such as bacterial examinations and biochemical analyses which are not available to farmers. Other sections of the book dealing, for example, with the diagnosis of pregnancy, do not stress the time and practice needed to acquire skill in the technique.

The book is an excellent one of its kind and contains much valuable information, and, in the foreword, the author warns his readers not to take chances with sick

animals, but to seek veterinary advice in cases of uncertainty; but it does tend to encourage farmers to perform for themselves services which would be more efficiently provided by the veterinary profession.

J. O. L. King

D'ARCY WENTWORTH THOMPSON

D'Arcy Wentworth Thompson

The Scholar-Naturalist, 1860–1948. By Ruth D'Arcy Thompson. Pp. xi+244+8 plates. (London: Oxford University Press, 1958.) 25*s*. net.

ALL of us who knew D'Arcy Thompson personally and the many who made his acquaintance through the pages of "Growth and Form" have reason for gratitude to his eldest daughter for this finely written biography. It brings vividly into memory that majestic figure and ponderous, admirably phrased utterance. There has been, as all must agree, no one like him in the world of zoology, or possibly in that of any other science, in our time.

He outlived his contemporaries, and most of us who knew him first met him as the author of "Growth and Form" and professor of natural history at St. Andrews, already on the high plateau of the last half of a professorial career that was to extend over sixty-four years. Of how many people would one remember the very first words heard from them? But there is vivid recollection of the opening phrase in an address he delivered before the Royal Physical Society of Edinburgh some thirty-five years ago. Speaking of Johannes Schmidt and his then recent discovery of the breeding places of the eel, he began, "Aristotle"—a long pause and then again—"Aristotle, who knew a little about everything but not everything about anything . . ." and we were launched on an account of modern achievement against a background of classical knowledge.

But, as we learn with so much interest from this 'life', the journey up to the summit of achievement and recognition had been full of disappointments. The chair at Dundee, obtained at the age of twenty-four, was after all a poor alternative to the fellowship at Trinity, Cambridge, that he had hoped for, and there were repeated failures to obtain other chairs or museum directorships. No comparative anatomist, he was out of step with his contemporaries and had he died before the publication of "Growth and Form" (when he was already fifty-seven) he would have had scant attention in any subsequent history of zoology.

His achievements to that date lay primarily in the fields of classical scholarship and of fisheries statistics. Even the two visits to the North Pacific as the United Kingdom representative on the Bering Sea Commission in 1896 and 1897, description of which forms perhaps the most interesting chapter in this book, brought him governmental rather than scientific recognition.

All changed in 1917 after the publication of "Growth and Form", and fame was assured. In this remarkable book his wide knowledge, his mathematical ability and, above all, the wide philosophical outlook which he shared with the Greeks whom he studied and so much admired, find full scope. Supremely well written, it has had a major influence on the direction of biological thought and research, the latter the more surprising because its author was not himself an experimentalist. In a postscript to this biography, Prof. P. B. Medawar contributes a critical essay of high distinction on "Growth and Form".

Perhaps the only criticism concerns the illustrations which could, one feels, have been better chosen. But taken all in all, this is a biography not unworthy of its subject and one that should be widely read and the more treasured as time passes, and with it the memory slowly fades of a great zoologist and a most remarkable personality.

C. M. Yonge

ALEXANDRE COLLIN—A PIONEER IN SOIL MECHANICS

Landslides in Clays

By Alexandre Collin, 1846. Translated by W. R. Schriever, with the assistance of J. P. Carrière, R. F. Legget, and D. H. MacDonald; with a Memoir on Alexandre Collin by A. W. Skempton. Pp. xxxvi+160+21 plates. (Toronto: University of Toronto Press; London: Oxford University Press, 1956.) 52*s*. net.

A REFERENCE which appears in all the standard soil mechanics text-books is to Alexandre Collin's "Recherches Expérimentales sur les Glissements Spontanés des Terrains Argileux" (Carilian-Goeury, Paris, 1846). It is a work that has been more quoted than read, and the translation by W. R. Schriever, entitled "Landslides in Clay", is most welcome, for the full text of this work, which is of great historic interest, can now be read by a wide public.

Historically, the work is important to civil engineers, for Collin was much ahead of his time; indeed, nothing approaching the quality of his work was done in soil mechanics for another fifty years. He used the inductive approach, carefully measuring up landslides when they occurred and basing his theories on the considerable amount of field evidence which he had collected. These data are still of value. Others of his contemporaries were deriving mathematical formulæ which bore little relation to the soil to which they were applied.

The analysis of slope stability as carried out to-day is fundamentally that outlined by Collin. He did not, however, attach great importance to this analysis and it is relegated to an appendix in the book.

His description of how he measured the mechanical properties of clay is also very interesting. He demonstrated how clay swells and shrinks with a change in water content, and showed how the shearing resistance also changes. This he measured by applying loads to specimens 4 cm. × 4 cm. in section, producing a double shear failure.

It is difficult to understand why this research was not followed up, and in a memoir on Collin, published with the translation, Prof. A. W. Skempton provides some reasons for it. The memoir is helpful, for it evaluates Collin's work not only in its contemporary setting but also shows where it lies in terms of our present-day knowledge.

Translating such a work cannot have been easy, but the English is extremely readable while yet retaining the feel of a work written in French more than one hundred years ago. To read it is a delightful and instructive recreation.

K. L. Nash

Health Yearbook, 1956

Compiled by Prof. Oliver E. Byrd. Pp. vi+278. (Stanford, California: Stanford University Press; London: Oxford University Press, 1957.) 40*s*. net.

SINCE 1943 the University of Stanford has published an annual Health Yearbook. Over the past few years these have been compiled by Prof. O. E. Byrd, professor of health education, who has brought to his task both diligence and zeal removed from the ordinary. For the 1956 Yearbook Byrd read some 2,000 articles culled from more than 300 health journals. From these he has chosen 254 which constitute a representative sample of the published health literature for 1956. The essence of each article has been patiently distilled and then set down by Byrd in language which would commend it to health educationists, both lay and professional.

The topics discussed include problems of rehabilitation, physical fitness, mental health, heredity and eugenics, infection and immunity, chronic and degenerative disorders, habit-forming substances, dental health, and safety, as well as the facilities available through health authorities, occupational and community health services. There is also a chapter giving accounts of developments in the international health education field, particular attention being paid to Western Germany, South America, Puerto Rico, India, the Soviet Union and Central Africa.

Although most of the book will be of most value to American readers, the editor has chosen his articles so wisely that a large part of it will be of interest and value to health educationists everywhere. Even in matters concerned with the United States, Prof. Byrd has risen above the parochial to set out general principles of health education rather than its local application. Inevitably there is over-lapping and some of the topics appear to hold most interest for the original authors. Yet it is surprising in a compilation of this kind how much of general interest the editor has brought together in a work which will be of value to all those looking for a résumé of important developments in health education during recent years.

K. M. HAWKINS

Commonwealth Universities Yearbook, 1958

Pp. xxvii+1337. (London: Association of Universities of the British Commonwealth, 1958.) 84*s*.

THE expansion in both size and numbers of the universities of the United Kingdom and of the British Commonwealth has led over the years to a corresponding growth in the Universities Yearbook, which had evolved into a squat bulky volume; the last edition contained more than 2,000 pages. Now the 1958 edition of this valuable work of reference has been issued in a new and much improved format comprising some 1,300 pages of larger size, set in a clearer type from which the subject headings stand out boldly. It is bound between dark blue, dirt-resistant covers. The contents of the book have also been completely rearranged. Hitherto, the United Kingdom has always come first, but now the Commonwealth countries are taken in alphabetical order, headed by Australia, Canada, Ceylon and Ghana. The United Kingdom comes near the end after Uganda, and followed only by the West Indies and an appendix on certain universities—in the Republic of Ireland and the Sudan—having close historical ties with the Commonwealth.

Another distinctive and particularly valuable feature of the new edition is a series of authoritative essays by distinguished academic writers, introducing the sections dealing with Australia, Canada, India, South Africa and the United Kingdom, and describing the system of education in each of these countries leading up to the several university institutions. These essays deal with the history, constitution, relations with the government, and finance of the universities in the countries to which they relate, with sections on pre-university education, conditions of admission and the courses available. Together they form an exceptionally valuable survey of the diverse educational and university systems obtaining in various parts of the Commonwealth.

The directories of the individual universities retain most of the features which have characterized previous editions. They give details of the staffs, activities, regulations and histories of each up to May or June 1957 and in some cases to a rather later date. There is also an appendix giving a statistical analysis of the 10,433 students from overseas enrolled at universities in Great Britain for the academic year 1956–57, and an index of nearly 40,000 names, including all university teachers and administrative officers mentioned in the text.

The Association of Universities of the British Commonwealth is to be congratulated on the changes, which still further enhance the value of this distinguished compendium of basic information indispensable to educationists and to all who are concerned with academic matters.

Bergey's Manual of Determinative Bacteriology

By Prof. Robert S. Breed, Prof. E. G. D. Murray and Nathan R. Smith. Seventh edition. Pp. xviii+1095. (London: Baillière, Tindall and Cox, Ltd., 1957.) 120*s*.

THE Bergey Manual is unique among books on bacteriology and a new edition can only be compared with earlier ones. The seventh has been greatly improved by the deletion of material, chiefly of interest to the nomenclaturist, which is to appear in a companion volume, the "Index Bergeyana".

The Manual has a twofold task: to give details of the cultural characters of well-defined species, and to indicate how these species may be collected together into genera and higher ranks. Success in the first depends on the individual authors (there are about a hundred of them) responsible for the particular sections. The new edition is better than the last because many more specialists are included among these authors, and the editorial board has concentrated more on general policy than on writing individual sections. Some of the larger sections, for example the family Enterobacteriaceae, would have been better co-ordinated if they had been written by a group of workers or by the appropriate international taxonomic subcommittee.

As a guide to taxonomic thought the Manual has generally been in advance of similar thought on the eastern side of the Atlantic. In the new edition the thought is still there but it is conventional, and does not seem to be aware that many bacteriologists now question the applicability of a hierarchical system to the classification of bacteria. There is an implicit acceptance of the species concept, and the taxonomic precepts put forward are not likely to be accepted by those whose ideas and thoughts go beyond the immediate identification of the organism. S. T. COWAN

FURTHER STUDIES ON THE PROCESS OF SONG LEARNING IN THE CHAFFINCH (*FRINGILLA COELEBS GENGLERI*)

By Dr. W. H. THORPE, F.R.S.

Madingley Field Station of the Department of Zoology, University of Cambridge

THE songs and other vocalizations of birds are of theoretical interest to both zoologists and psychologists. This is so because, first, they act as social communication systems and as a means of expression—in other words, as a language. Secondly, they provide specific recognition marks which suggest important problems in ecology and evolution. Thirdly, they pose problems concerning the inheritance and genetical control of extremely elaborate behaviour patterns. Finally, the vocalizations of birds can be regarded as offering particularly crucial problems concerning the acquisition of complex behaviour patterns as a result of individual learning.

In an article in *Nature* four years ago[1], it was shown that the normal song of the chaffinch (*Fringilla coelebs*) is an elaborate integration of inborn and learned components, the former constituting the basis for the latter. The present report summarizes very briefly progress which has been made since then. The full account of all the experiments will appear shortly[2].

A good example of a normal song of *F. c. gengleri* is given in Fig. 1. The inborn component of the chaffinch song can be revealed by hand-rearing the young birds from the early nestling life either in acoustic isolation or at least out of contact with all chaffinch song. Six birds thus individually isolated produced songs of an extremely simple type (Figs. 2–4) consisting of a song burst of approximately the correct length (2–2·5 sec.) made up of about the right number of notes. The pitch, or fundamental frequency, of these notes was somewhat lower than normal, and the songs produced by these isolates lacked the division into the three phrases so characteristic of the normal chaffinch song. Moreover, the final flourish and all the other fine details by which the chaffinch song is normally recognized as such were also absent. Of all the hundreds of wild and aviary-kept birds which have passed through our hands during the course of these experiments, none has produced songs of such extreme simplicity as these six birds, although such undeveloped songs are known to occur in the wild at times.

In contrast to the simple, restricted song produced by the isolated birds, we find that if, after babyhood, two or more such birds are put together in a room but still without the opportunity of hearing experienced chaffinches, they will develop more complex songs. It seems that the attempt to sing in company produces mutual stimulation which encourages the development of complexity. The members of each group of hand-reared birds thus kept together will, by mutual stimulation, build up a distinctive community pattern. The birds conform so closely to this pattern that it is sometimes barely possible to distinguish the songs one from another even by electronic analysis. The song of such birds may be quite as complex as that of a normal wild chaffinch, but its complexity tends to be of a different kind and a song thus produced may bear little resemblance to the characteristic utterances of the species. From further experiment it is clear that in the wild, young chaffinches learn some features of the song from their male parents or from other adults during the first few weeks of life. But most of the finer details of the song are learned by the young bird when, in its first breeding season, it first comes to sing in competition with neighbouring territory-holders. There is little doubt that this is the way in which local song dialects are built up and perpetuated. In addition to this true song, the chaffinch, like many other species, has what has been called a sub-song, which is a much quieter and less aggressive affair than is the full song. It is, however, not merely a song of low intensity: it is of an entirely different pattern from the true song and may be described as a long succession of chirps and rattles[2–4]. It seems to have no communicatory

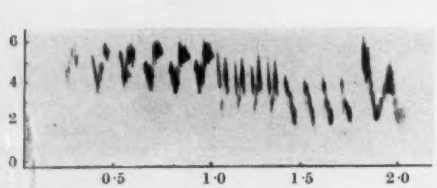

Fig. 1. 'Normal' song of British chaffinch (*Fringilla coelebs gengleri*) *BW/P*, May 9, 1952. Vertical scale: frequency in kc./s. Horizontal scale: time in sec. (Similarly in Figs. 2–11)

Fig. 2

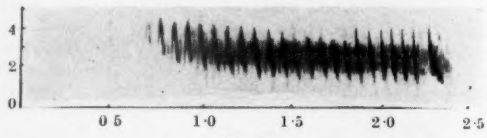

Fig. 3

Fig. 4

Figs. 2–4. Song of three hand-reared auditory isolates. *GW*, June 24, 1954; *B/BkY*, May 25, 1957; and *BkW/W*, June 24, 1955

function and is most frequently heard in the early spring, when it is produced, so far as we know, much more by first-year birds than by older ones—the latter seeming to come into full song with much less of this preliminary sub-song. There seems little doubt, however, that the sub-song provides in some degree the raw material out of which, by practice and by the elimination of unwanted extremes of frequency, the full song is 'crystallized'. The chaffinch has, of course, like other species, a number of call notes which are in the main signals for co-ordinating the behaviour of the flock, mate and family; some of these may be used as components of both sub-song and full song. It is interesting that call notes are much more in evidence as components of the songs of isolated birds than they are in the songs of normal ones. This is presumably because the isolated birds have had a greatly restricted auditory experience to draw upon as compared with normal wild individuals.

Chaffinches are not imitative birds, in that they do not normally copy anything but sounds of chaffinch origin. Once a chaffinch has heard a chaffinch song as a young bird in the wild, it appears to have learned enough about it to refuse to copy any sound pattern which departs far from the normal; that is, it will learn only the finer individual variations of the song of other chaffinches. So, in the wild, chaffinches practically never, in their full songs, imitate anything but other chaffinches. Hand-reared, isolated birds will learn songs of far greater abnormality, however, provided always that the tonal quality is not too different from that of a chaffinch song. Voices as 'abnormal' as that of a domesticated canary (*Serinus c. canarius*) may be learned by hand-reared birds[3], and very occasionally by wild birds; but when this happens the alien notes are kept as components of the non-communicative sub-song only; the full song is not contaminated with them.

If one catches wild chaffinches in their first autumn and keeps them until the following spring with other chaffinches the song of which is already fixed, one gets clear evidence that the young birds have modelled their songs, in some respects at least, on those of their associates, which have probably come into song first as the spring season comes on, and which they thus hear before they themselves have got very far along the path of song production. Similarly if, instead of exposing such wild-caught first-year birds to the songs of other chaffinches, one plays such songs to them by means of the repeating tape machine which we call a 'song tutor', a clear positive effect is manifest. An experiment carried out in 1954–55 with four wild-caught birds given such tuition in the winter (January 6–20) and with three birds similarly treated in February–March showed clearly the effect of the 'song tutor', there being correct articulation of the phrases and a good approximation in pitch and quality, although there were abnormalities in length and emphasis. If, however, under these conditions one exposes the young birds to highly abnormal songs, no result is obtained. Thus in experiments in 1955–56 such birds were given tuition with a reversed chaffinch song during March. The fact that no definite effect was obtained suggested that enough of the song had already been learned in the autumn for the reversed song to be ineffective even with visually isolated birds. In 1956–57 a similar experiment was done using six wild-caught autumn males and exposing them, in this case not to a reversed song, which was thought to be perhaps too abnormal, but instead to three different 're-articulated' songs (these are songs

Fig. 5

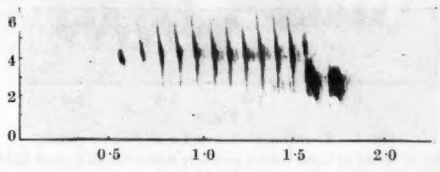

Fig. 6

Figs. 5 and 6. Two songs of a hand-reared auditory isolate after having been exposed to normal song on the 'song tutor' for 10 days only during November of its first year. *GY/BW*, April 24, 1956

in which the position of the three phrases has been interchanged). In this experiment the birds were isolated in a soundproof room. Two birds had exposures in September and October, repeated in January, two had exposures in mid- to late-October and late January and early February, and two were similarly exposed in November and February. On the whole, this experiment also had little effect, confirming the tests with the reversed song and suggesting even more strongly that the natural training which the bird has already received by the time it has reached its first winter moult has equally been sufficient to prevent it from learning afterwards the rather large abnormalities characteristic of these re-articulated songs.

When we come to similar experiments with hand-reared birds, very different results are obtained. It was found that a hand-reared visual isolate can be taught features of a normal song from the tape by being exposed to it during November only of its first winter for a period of 10 days. Figs. 5 and 6 give the two songs developed in 1956 by such a bird treated in 1955. The first song shows clearly the influence of the 'tutor', in that it has three phrases otherwise unknown in a hand-reared isolate, having a clear stepwise descent but no end phrase. The second song is of the isolate type plus two end-notes. These experiments thus produce evidence that tutoring, even for a short period in November, can effect the same kind of result as the normal song experience of a wild bird in the field during the autumn. Similar positive results were obtained in similar experiments with re-articulated songs carried out in 1956–57 and 1957–58. Figs. 7 and 8 show such a re-articulated model and its effect on the song of a hand-reared isolate. Hand-reared birds show similar differences from the wild-caught ones, in that if given a reversed song a considerable amount of copying is achieved. Similar experiments with other birds provide further evidence for a previous conclusion that although a hand-reared isolate is incapable by itself of producing anything approximating to a normal ending, yet if once it hears a normal end-flourish on the 'song tutor' (even though in the re-articulated song on the tape it occurs at the beginning or in the middle of the song) it will recognize it as appropriate for an ending and will attempt to place it properly in its own song.

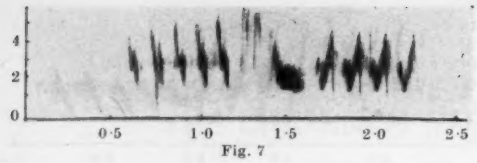

Fig. 7

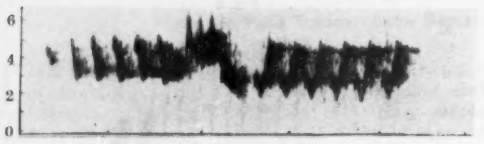

Fig. 8

Fig. 7. Re-articulated model with 'end in middle'

Fig. 8. Song of hand-reared auditory isolate *B/BkP* after having been exposed to this model for 12 days January–February and 12 days February–March. March 25, 1958

In experiments in 1954–55 an attempt was made to indoctrinate hand-reared isolate chaffinches with the song of the tree pipit (*Anthus trivialis*) (Fig. 9), this being chosen because the spectrograph reveals that the tonal quality of the notes is similar to that of the chaffinch. The first experiment gave a doubtful result; but a repeat in 1956 resulted (Fig. 10) in the achievement of a remarkably good copy by such a chaffinch of the song of a tree pipit, resulting in a chaffinch song entirely unlike any other produced in my experience by a wild or hand-reared bird. It is of interest to note that the rather long song of the model has been condensed to conform to the standard length of chaffinch song by condensing the middle phrase of the tree pipit song to two notes instead of four. This song became still further 'tightened up' and shortened by the beginning of May (Fig. 11).

The reason why chaffinches do not imitate and acquire songs from other species in the wild now

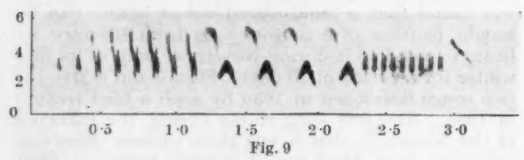

Fig. 9

Fig. 10

Fig. 11

Fig. 9. Song of Continental tree pipit (*Anthus trivialis*) used for tutoring

Fig. 10. 'Copy' of tree pipit song produced by chaffinch *R/R* after tuition on 'song tutor', April 21, 1956

Fig. 11. 'Improved' tree pipit copy. *R/R*, May 3, 1956

seems fairly evident. There is little doubt that they restrict their imitativeness to the right models as a result of being responsive only to notes of approximately the right tonal quality. It is interesting that the imitation of the tree pipit song just referred to is the best copy of an alien song so far obtained. Here the tonal quality of the model was right, although the song itself was much too long and the phrasing of the notes of the model abnormal from a chaffinch point of view.

To summarize this work with the 'song tutor', it can be said that in eleven experiments carried out over the years 1955–57 and involving thirty-four wild autumn-caught first-year males, the only positive effect obtained (in the sense of a significant similarity between model and mimic) occurred in two experiments (seven birds) only, and in these two the model was a normal chaffinch song. Of the remaining ones (nine experiments, twenty-seven birds) the models were always abnormal—the songs being artificial, re-articulated or reversed—and the results were always negative. The contrast when hand-reared isolated birds are used is striking. Thus during 1954–59, thirteen experiments involving sixteen hand-reared birds were carried out using similar song models. Of these, ten experiments (eleven birds) were positive in the sense of yielding a significant effect. The remaining three experiments (five birds) gave a negative result.

The counter-singing that occurs between birds in adjacent territories is an important factor in stimulating and restricting the imitative abilities of chaffinches. When a chaffinch has acquired more than one song-type, each song-outburst consists of a sequence of one song-type followed by a sequence of another. When songs are played back to a chaffinch, we find that those songs which it uses most frequently itself are the most effective in evoking song[5]. A chaffinch in the wild will thus tend to reply to a neighbour with that song of its own repertoire which most nearly resembles the song of its rival.

It is suggested that, with the more 'imitative' finches such as the bullfinch (*Pyrrhula pyrrhula*), hawfinch (*Coccothraustes coccothraustes*) and to some extent greenfinch (*Chloris chloris*), the song, while functional in co-ordinating the breeding cycle and behaviour of the mated pair, is of less importance as a territorial proclamation. Thus in some respects it resembles the sub-song rather than the full song of the chaffinch; similarly, contamination with alien notes can be tolerated to an extent which might be very disadvantageous in a strongly territorial song that must maintain its character as a reliable specific recognition mark. A preliminary study of a number of species of buntings shows that many of the species, for example, reed and corn buntings (*Emberiza schoeniclus* and *E. calandra*), have songs which are highly stereotyped and completely innate. The song of the yellow bunting (*E. citrinella*) appears to consist of an integration of innate and learned components much as in the chaffinch. The buntings as a whole appear to have strongly territorial songs corresponding in function to that of the chaffinch.

Apart from a very few and partial exceptions, chaffinches can learn song patterns only during the first thirteen months of life, and towards the end of this time there is a peak period of learning activity of a few weeks during which a young chaffinch may learn, as a result of singing in a territory, the fine details of as many as six different songs. This special period of high learning ability is brought to an abrupt

close by internal factors. It matters not whether a chaffinch has learned one or six songs by the time it is thirteen months old, it can afterwards learn no more, and so it remains with its one song or its six for the rest of its life. This restriction of learning ability to a particular type of object and to a sharply defined sensitive period recalls the phenomenon of imprinting.

The inborn recognition and performance of its specific song by the chaffinch involves (*a*) duration of approximately 2½ sec., (*b*) interval between songs of between 10 and 20 sec., (*c*) tonal quality (though this last may have been learned by the experience of the bird of the qualities of its own voice). The readiness with which the bird learns to divide its song into three sections and learns to attach a simple flourish at the end as an appropriate termination shows that there must be an imperfectly inherited tendency to respond to, and perform, the features of the normal song as soon as the singer is stimulated by hearing another bird. Such an inherited tendency would explain the basic similarity of the songs of the species throughout its range.

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THE ELECTRON TEMPERATURE IN SCEPTRE III

By Dr. S. KAUFMAN and R. V. WILLIAMS
Research Laboratory, Associated Electrical Industries, Limited, Aldermaston

IN high-current discharges of the type observed in ZETA and SCEPTRE[1] thermodynamic equilibrium does not exist, and the ions and electrons may be at different temperatures. The Doppler broadening of spectral lines is evidence of large ion velocities, although it has yet to be shown conclusively that the motion is associated with a real ion temperature. On the other hand, no results have yet been published on the electron temperature T_e.

In general, it should be possible to determine T_e from a study of spectral excitation by electron impact, and qualitative variations in electron temperature for different conditions of the SCEPTRE discharge were at first observed from the relative strengths of spectral emission in different stages of ionization (for example, O V/O IV)[2]. However, an absolute determination of T_e is generally difficult because of the multiplicity of processes which can populate an atomic level. It is proposed that this problem can be simplified if a suitable atom of the He I iso-electronic sequence is chosen. From a preliminary measurement of the absolute intensity of a C V spectral line, T_e has been estimated to be $2{\cdot}5 \times 10^5$ deg. K. to within a factor 2, on making the basic assumption that run-away electrons do not contribute appreciably to the excitation.

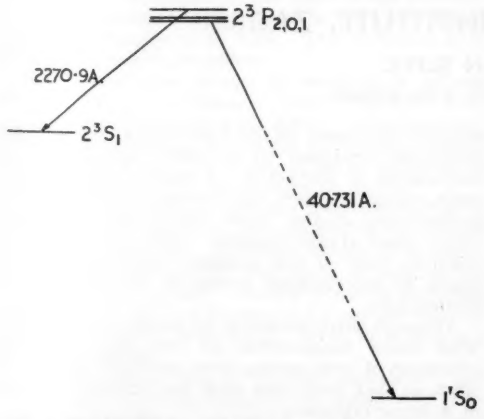

Fig. 1. Partial Grotrian diagram of the He I iso-electronic sequence. Wave-lengths and relative positions of the triplet lines refer to C V

Atoms of the He I iso-electronic sequence are particularly stable. For example, while the ionization potential of C IV is only 64·5 eV., the lowest excitation potential (E_{12}) of C V is 304 eV., excluding the neighbouring 2^3S metastable level (Fig. 1). Thus, cumulative processes from previous stages of ionization are comparatively unimportant and it is assumed that the C V spectrum will not be excited appreciably until all the carbon atoms are in the ground-level $1\,^1S$ of C V (cf. the conditions in Wolf-Rayet stars[3]). We also suppose that the 2^3P_2 level of C V is filled entirely by electronic excitation from this level (population N_1). The competing processes which populate the 2^3P_2 level (cascade from upper levels and electronic excitation from the 2^3S level) and de-populating processes other than radiation (namely, electronic excitation and super-elastic collisions from the 2^3P_2 level) are neglected; their effect on the measured temperature is considered below. The transition $1\,^1S_0$–2^3P_2 is forbidden for dipole radiation. In the steady state which is attained after about 10^{-7} sec., the rates of electronic excitation of the 2^3P_2 level and radiation from this level by the line (2^3S–2^3P_2) at 2270·9 A.[4] will therefore be equal. Hence, the specific intensity I of this line is

$$I = 2\left(\frac{2kT_e}{\pi m}\right)^{\frac{1}{2}} N_1 n Q_{12} h\nu \left(1 + \frac{E_{12}}{kT_e}\right) \exp\left(-\frac{E_{12}}{kT_e}\right)$$

where k is Boltzmann's constant, m the electron mass, n the electron concentration, h Planck's constant and ν the frequency of the spectral line. The cross-section Q_{12} for electron impact from the $1\,^1S$ to the 2^3P_2 level is finite at the threshold energy and, for simplicity, is regarded as invariant with energy above threshold. Measurement of the absolute intensity of this C V line therefore permits an evaluation of T_e, providing the other parameters are known.

The line at 2270·9 A. was first identified on several spectrograms but was faint and broad; the other members of the triplet were too weak for exact identification. To demonstrate this method of

estimating T_e, a preliminary experiment was conducted under discharge conditions where the excitation of the O V line (2781 A.) was intense, namely, deuterium at a pressure of 1·4 millitorr, the condenser bank charged to 25 kV., turns ratio 16 : 1, initial toroidal magnetic field of 500 oersteds and peak gas current $1{\cdot}2 \times 10^5$ amp. Methane at a partial pressure of 3×10^{-5} torr was added to the deuterium to strengthen the C V emission and provide an estimate of N_1. The temporal and spatial intensity distributions of the line at 2270·9 A. were obtained with a combination of a monochromator and a photomultiplier. The intensity I of this line at peak excitation averaged over the central region of the torus was measured to be 4×10^3 erg. sec.$^{-1}$ cm.$^{-3}$. Peak excitation occurred at approximately peak current, which was unchanged by the introduction of the methane. From the above relation and taking the value of Q_{12} at threshold to be $1{\cdot}8 \times 10^{-17}$ cm.^{2} ($0{\cdot}2\,\pi\,a_0^2$), T_e was found to be $2{\cdot}5 \times 10^5$ deg. K.

It is fortunate that at about this temperature the exponential factor in the above relation is extremely sensitive to the smallest change in T_e. Therefore, only the order of magnitude of $N_1 n Q_{12}$ need be known and considerable latitude can be permitted for the magnitude of competing processes. In the estimation of N_1 we are justified in assuming that most of the carbon atoms are in the C V ground-level, for the excitation of the O IV line at 3063 A. was a minimum at the torus axis. If instead of the above excitation mechanism it is assumed that the dominant excitation of the 2^3P_2 level is from the 2^3S level, the electron temperature can still be calculated because the populations of the 2^3S and ground-levels are governed approximately by Boltzmann's distribution law. Even if Q_{m2}, the cross-section for this process is taken as large as 100 Q_{12}, T_e is only altered to $2{\cdot}0 \times 10^5$ deg. K. Super-elastic collisions from the 2^3P_2 level are relatively unimportant for the assumed value of Q_{12}. If this process were very much greater so that it predominated over radiation, the populations of the 2^3P_2 and ground-levels would also be determined by Boltzmann's distribution law: the calculated temperature would again be $2{\cdot}0 \times 10^5$ deg. K. The principal cascade effect to the 2^3P_2 level, namely, from the 3^3D term, is scarcely likely to alter the population of the 2^3P_2 level radically, for it is situated 50 eV. above this level. This large energy jump also reduces the compensating process of electronic excitation from the 2^3P_2 level. If the estimation of the coefficient of the exponential in the equation is considered to be in error by a liberal factor, namely, either 10^{-3} or 10^3, a range of $(1{\cdot}7\text{–}5{\cdot}2) \times 10^5$ deg. K. would be the uncertainty in T_e. For higher values of T_e, it will be important to know the magnitudes of Q_{12}, Q_{m2}, N_1 and n more exactly. Further theoretical and experimental work is in progress and it is hoped to publish a fuller account at a later date.

A value of $2{\cdot}5 \times 10^5$ deg. K. for T_e is consistent with qualitative observations of the plasma's electrical conductivity and O V emission. However, the need to explain the large Doppler widths which are observed is even more compelling than hitherto. Spitzer's suggestion[5] as extended by Gabor[6] that co-operative phenomena between the electrons and ions are responsible for the large ion velocities, need not be called into play.

We acknowledge our indebtedness to Dr. M. J. Seaton (University College, London) for having suggested to us the possible order of magnitude of Q_{12}, and to Prof. B. Edlén (University of Lund) for his assistance in the identification of the C V triplet. We are also grateful to Mr. T. P. Hughes for photographing the spectra, to Dr. A. A. Ware for his interest and comments on the manuscript, and to other colleagues of the Thermonuclear Section for their active help in running SCEPTRE III. We also acknowledge helpful discussions with our colleagues at the Atomic Energy Research Establishment, Harwell.

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RUDJER BOŠKOVIĆ INSTITUTE, ZAGREB

By Prof. IVAN SUPEK
President of the Council of the Institute

THE decision to found the Rudjer Bošković Institute was taken by the Yugoslav Federal Government in May 1950. At this time the building of the Boris Kidrič Institute, Vinča—the first institute for nuclear sciences in Yugoslavia—was almost complete, and that of the Jožef Stefan Institute in Ljubljana had just begun.

Although the emphasis is on nuclear physics, the Council of the Rudjer Bošković Institute intends to include activities in the fields of chemistry and biology. For this reason, laboratories for physical chemistry and biochemistry were built in 1952, and two years later two fairly large buildings, originally barracks, were adapted as biological laboratories.

The newly formed Council of the Institute wished to establish a firm basis for fundamental research in nuclear energy. The main problem was the need for scientific personnel on one hand and an insufficiently developed tradition of scientific training in the universities on the other. A large number of graduates, therefore, were sent abroad to continue their postgraduate studies. Most of them went to England, where they always found a ready welcome. For example, four of our students took their doctor's degree in experimental physics at the University of Birmingham.

Although three institutes for nuclear research work were under construction at the same time, the allocation of work among them was made at the very start, so that since then each has functioned as part of a larger organism.

As the Institutes in Vinča and in Ljubljana were chiefly interested in reactor physics, the Council of the Rudjer Bošković Institute decided at the end of

Fig. 1. The Rudjer Bošković Institute. The physical and chemical laboratories with the service and workshop buildings behind. The cyclotron house is underground on the right, the natural formations providing adequate screening

1950 to build its own cyclotron for the investigations in nuclear physics as well as for specialized techniques in the application of radioactive isotopes. A group of young engineers, therefore, after seeing some cyclotrons in Europe, made a detailed plan for a cyclotron to be constructed by themselves. This cyclotron will be the biggest machine for nuclear research in Yugoslavia, planned and built within the country, and with most of the instruments provided by domestic industry. The deuteron beam is expected to have an energy of 16 MeV. The cyclotron is to be a variable energy machine.

Two experimental groups for research on nuclear structure have been formed; their work will centre around the cyclotron and the 200 kV. neutron generator. In addition, there is a theoretical department which is working on the theory of fields, the study of nuclear structure, and the theory of metals.

From the beginning there has been a tendency to manufacture as much of the apparatus as possible within the Institute. A well-equipped Electronics Department was therefore organized as soon as the Institute was founded. Various types of counters, scalers, as well as other apparatus for nuclear research work have already been made. Work on transistors is also in progress.

There are two groups for physical chemistry: one dealing with structure analysis, the other with technological problems, especially those concerning nuclear raw materials. Great pains are being taken in the production of semi-conductors and of other crystals which are of importance to industry. New

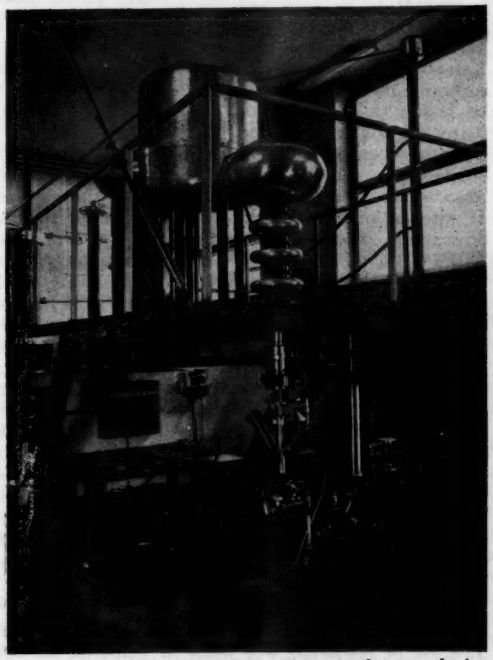

Fig. 2. One of the accelerating machines in the pure physics section

methods for the study of chemical processing problems are being introduced. Work in the tracer laboratory has been going on for three years in collaboration with the biology department, primarily on the compounds labelled with carbon-14.

Besides these investigations with weak radioactivities, a group for radiochemistry has been formed which will study materials which have been irradiated with the cyclotron and the application of radioactive isotopes in chemistry.

The basic task of the biochemical department is the synthesis of protectors against radiation, and recently emphasis has been laid on antibiotics. Investigations with labelled organic compounds are also in the biochemistry programme.

The research work in biology is mainly concerned with basic effects of radiation on living organisms, single-cell organisms and viruses being studied on one hand, and complex organisms on the other. Some of the biological work was begun in the Medical Institute of the University of Zagreb, and is now being continued in the Department of Biology.

The Scientific Council has always believed that the Institute and the University should be united by common efforts in research work as well as in the training of young scientists. In 1953 the University and the Institute Council decided to unite their efforts in the fields of work common to them and a postgraduate school was organized in the Institute in 1957.

The Institute is financed by the Federal Atomic Energy Commission, which also approves the annual research plans and co-ordinates work with that of other institutes in the country. Industry and other institutions, besides the Commission, support research work outside the field of nuclear energy.

At present about 400 people are working at the Institute. The number of scientific personnel is about 140 and it is hoped that this will increase next year. Technical staff working in the laboratories number about 60, and there are about 60 workers employed in the Institute workshops. Eventually the Institute will employ about 600 people.

Some experts of the Great Powers may look sceptically upon the efforts of small countries. Certainly, we cannot enter the race in big technical undertakings in the field of nuclear energy and we do not wish to. Our intention is to take part in fundamental research and to help build a solid basis for peaceful applications. But still more than this, the present state of the world, split into armed camps, has disrupted the internationalism of science. In this situation, on the verge of the suicide of the whole of mankind, the renaissance of a universal spirit is an aim, in the realization of which small countries like Yugoslavia can help a great deal.

NEWS and VIEWS

Research Association of British Rubber Manufacturers: Dr. J. R. Scott

The recent announcement that Dr. W. F. Watson has been appointed director of research of the Research Association of British Rubber Manufacturers might suggest that the rubber industry would be losing the services of Dr. J. R. Scott, but his many friends will be glad to know that this is not the case, because he is to be appointed to the newly created post of scientific adviser to the Research Association. Those who have followed the advance of international standardization will have realized how much progress has been made by Committee *ISO/TC/45*, on Rubber, of the International Organization for Standardization. This has been largely due to the painstaking work which Dr. Scott has put in as leader of the United Kingdom delegation. The patient and well-informed manner in which he dealt with international differences in opinion serves as a model of diplomacy which could well be followed by others. He is expected to lead the delegation to the next meeting, to be held in the United States in the autumn of 1959. As Dr. Scott will not be retiring in the near future, it is sufficient to note that he has already had thirty-five years service with the Association, and that he was the second holder of the post of director of research, succeeding the late Mr. B. D. Porritt on the latter's death in 1940.

Dr. W. F. Watson

Dr. W. F. Watson, who has been appointed third director of research, was born in Fifeshire in 1923 and obtained his Ph.D. when he was twenty-two, working at the University of Aberdeen under Prof. (now Sir Harry) Melville. He studied the theoretical treatment of copolymerization kinetics, the retardation and inhibition of polymerization reactions, the polymerization of methyl methacrylate initiated by its own polymer, and the diradical nature of photochemical and thermal polymerization. His work at Aberdeen was followed by a two-year postdoctorate fellowship at the University of Minnesota, sponsored by the United States Office of Naval Research, involving the absorption spectra of highly purified chlorophyll, for which he was awarded the D.Sc. degree of the University of Aberdeen at the age of twenty-six. His present work at the British Rubber Producers' Research Association is especially notable for studies of the way in which mechanical energy can be used to rupture molecular linkages, and he was the first to prove that this process occurred under the conditions obtaining in the mastication process. This development has opened up possibilities of obtaining interesting new materials, which have been confirmed on a commercial scale, and no doubt Dr. Watson will be continuing this work, as well as developing his novel single-rotor rubber mixer, at the Research Association.

Geology at the Imperial College of Science and Technology: Dr. John Sutton

Dr. John Sutton, reader in geology in the University of London, has been appointed to the University chair of geology at the Imperial College of Science and Technology, London, vacated three years ago by Prof. H. H. Read, whose work is de-

scribed in *Nature*, **176**, 490 (1955). Dr. Sutton has been associated with the Imperial College throughout his career as undergraduate, postgraduate research student, lecturer and reader—with a non-academic interruption by service in the Royal Electrical and Mechanical Engineers separating the first two stages. His early research work, done in collaboration with Dr. Janet Watson (Mrs. Sutton), dealt with the structural, metamorphic and plutonic history of the most ancient rocks, first of the Lewisian of the Scottish Highlands and then of the basement of East Africa. During the past decade, Dr. Sutton has built up at the Imperial College a research school concerned with the investigation in great detail of the structural history of the Moine Series of the Northern Highlands. Under his leadership, the complex history of this famous group of rocks has been patiently unravelled by meticulous field-work over considerable areas east of the Moine Thrust, and a firm foundation has been laid for a complete structural synthesis of Britain's most extensive formation. Agreeable to the definition of geology as earth-history, this work is marked by an appreciation of the importance of the timing of events in the production of crystalline schists. Under Dr. Sutton's direction in the field and the laboratory, a continued development of fundamental research in the metamorphic and plutonic rocks can confidently be expected at the Imperial College.

Seals and Nets

In its last annual report the Nature Conservancy reluctantly accepted the desirability of experimenting in strictly limited measures of control of the Farne Island grey seal population and recommended, as an experimental and interim measure, that further increases in the grey seal should be limited by an annual cull of 300 calves, if authorized by the Minister of Agriculture, Fisheries and Food by Order under the Grey Seals Protection Act, 1932. It also recommended continuation of research and observations on seals as at present and a new attempt, sponsored by the Scottish Home Department, to discover means of protecting nets against seals. Such an Order was laid before the House of Commons on July 10 and on July 28 a motion against the Order was made by Mr. A. Blenkinsop, who, in asking what the Government was doing to encourage further research into the problem and to strengthen nets, alleged that it had refused a grant to the Nature Conservancy to enable it to carry out this research work more effectively. Widely varying views were expressed in the debate, in which the risk of exterminating the grey seal, as had happened on the north Cornish coast, was recognized by supporters and opponents of the Order. The motion was withdrawn in view of the explanation by Mr. J. B. Godber, Joint Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, that no final decision had been taken as to the merits of culling as a means of controls and his undertaking to look into the possibility of assistance to further research work.

Committee on Grants to Students

The Ministry of Education and the Scottish Education Department announce that the Committee on Grants to Students set up recently under the chairmanship of Sir Colin Anderson (see *Nature*, **182**, 20; 1958) is now ready to receive written evidence. Any interested persons or bodies are invited to submit a memorandum to the secretaries (for England and Wales, Mr. D. Neylan, Ministry of Education, 14 Cornwall Terrace, London, N.W.1, and for Scotland, Mr. G. A. T. Hanks, Scottish Education Department, St. Andrew's House, Edinburgh 1), if possible not later than November 30. The terms of reference of the Committee are: "to consider the present system of awards from public funds to students attending first degree courses at universities and comparable courses at other institutions and to make recommendations". Among the questions which the Committee will be considering are the kinds of awards to be made from public funds, the method of selecting students for such awards and the principle of the hardship test required by the law as it now stands.

Adventures in Science

The Smithsonian Institution has just published a new popular science booklet for young people, designed to show "that science can be exciting and that science can be fun". Entitled "Adventures in Science at the Smithsonian", the illustrated 24-page booklet tells about a few of the scientific milestones that have marked the progress of civilization and shows part of the outstanding role that the Smithsonian has played in the advancement of science since its founding in 1846. Planned to appeal primarily to children in junior schools, "Adventures in Science" not only presents information about many different sciences in simple, easy-to-read form but is also extensively illustrated in colour with objects from the Smithsonian's collections. The booklet can be read in two ways—from front cover to back, or from back cover to front. The natural sciences occupy the first half of the publication, while the physical sciences and engineering occupy the second half. If the reader begins at the back page, he starts in the present—"Tracking Earth Satellites" —and reads back into time. If he starts at the front, he journeys from "The Dinosaur Age" to the present. The authors, E. John Long and George Weiner, have simplified the often prolix terminology of science. For example, the subject of anthropology is covered in the section entitled "Searching for Cave Men", and astronautics, or rocketry, is discussed in "Into Space". The price for single copies is 25 cents.

Laws in Social Science

One of the main points made by Sir Alexander Carr-Saunders in his recent Eleanor Rathbone Memorial Lecture at the University of Liverpool ("Natural Science and Social Science". Pp. iv+15. Liverpool University Press, 1958. 3*s*.) is that, despite many attempts by social scientists to discover laws and law-like correlations by using the procedures of the natural sciences, "nothing remotely resembling a law of the natural sciences has yet been produced". Carr-Saunders agrees with J. S. Mill who, in his "System of Logic", subjected the possibility of using natural science procedures in the social sciences to exhaustive analysis. His conclusions were that, because of what Mill called "the complication of causes" and of the impossibility of insulating the variables concerned from the large influences of extraneous factors, no laws can be established in the social sciences in this way. It is not surprising that none has been discovered. "If such laws could be discovered they would appertain rather to a world of ants than to a world of men."

Work of Sir Edmund Whittaker

THE *Proceedings of the Edinburgh Mathematical Society* of June 1958 is a worthy memorial to the late Sir Edmund Whittaker. An obituary notice by D. Martin is followed by papers on various aspects of Whittaker's work: harmonic functions (G. Temple); automorphic functions (R. A. Rankin); algebra and numerical analysis (A. C. Aitken); relativity (J. L. Synge); physics and philosophy (J. McConnell). Few mathematicians of our time have matched Whittaker's clear vision and deep knowledge of the whole field of modern mathematics. To young men he was always an inspiration, and to ensure that this inspiration shall not be entirely lost, his family has founded a Whittaker Memorial Prize for the encouragement of young mathematicians in Scotland; details are given in this number of the *Proceedings*.

The National Museums, Ceylon

THE annual reports of the National Museums in Ceylon for 1956 and 1957 (pp. 20+5 plates. 70 cents. Pp. 23+2 plates. 70 cents. Colombo: Government Publications Bureau, 1957 and 1958) record steady but not spectacular progress in all departments. The most outstanding discovery yet made in Ceylon was that of a Stone Age kitchen-midden in the Balangoda District containing a number of ceremonial burials in a flexed position. The skull is being reconstructed at the American Museum of Natural History and it is hoped that a carbon-14 test will be carried out in Britain. The Museum Week sponsored by Unesco in October 1956 was duly observed and important and instructive talks were given on Radio Ceylon.

Museum of Applied Science at Victoria

The annual report of the Museum of Applied Science of Victoria for the year ended June 30, 1957 (pp. 30. Melbourne: Museum of Applied Science of Victoria, 1958), is up to date, as it opens with a photographic illustration of a model of a space satellite now included in the museum collections. Another fascinating exhibit is a model of an oxygen atom with its twenty-four particles in rapid motion. Special exhibits were also displayed for the benefit of visitors to the Olympic Games in Melbourne in 1956. A series of large portraits of eight famous scientists, ranging from Galileo to Einstein, attracted much attention. The Museum has been fortunate in achieving two of its objectives of many years—the provision of a convenient store of adequate size and a hoist for moving massive objects to and from the main floor.

Technical Information Systems

THE Office of Scientific Information of the National Science Foundation has issued under the title "Non-Conventional Technical Information Systems in Current Use" (pp. v+43. Washington, D.C., 1958) a report briefly describing twenty-five representative systems of new design, covering the principles of operation of each system, the equipment and manpower required, the size of the group served and of the file and its rate of growth, with bibliographical references to any published information on the system. The report is purely factual and includes no comment or criticism of the systems described. Among these are the mechanized searching system for patents on steroid compounds used at the United States Patent Office, the hand-sorted punched-card file for geochemistry maintained at the United States Geological Survey, the mechanized indexing system for literature in pathology and biochemistry, using the *IBM* 101 statistical machine at the Documentation Centre of the Schering Corporation, and the 'peek-a-boo' system of co-ordinate indexing used, for chemical compounds tested, by the U.S. National Institutes of Health cancer chemotherapy programme.

Egyptian Scientific Institutions

To assist men of science who are interested in the development of science in Egypt, the Middle East Science Co-operation Office of Unesco has published a survey of all the scientific institutions in Egypt (pp. 149. Cairo: Unesco Science Co-operation Office, 1957). The institutions listed are concerned with teaching and research not only in the fields of pure science but also in engineering, agricultural and medical sciences. With the exception of various scientific societies, all these institutions are government bodies. The survey explains how scientific institutions are controlled by the Ministry of Education and also gives a clear account of the national educational system. Among the institutions described are the universities, the Science Council, the National Research Centre, Desert Institute, Atomic Energy Commission, Ministry of Agriculture, Ministry of Industry (Geological and Mineral Research Department, Mines and Quarries Department), Ministry of Commerce (Chemical Department), Ministry of Public Works (Nile Control Department), Ministry of Public Health, Ministry of War, the Egyptian Sciences Association, l'Institut d'Egypte, and the Egyptian Academy of Science. Names of leading members of the staffs of these organizations are included.

University Theses

THE Committee of the University and Research Section of the Library Association set up in 1952 a small sub-committee to investigate ways and means of publishing detailed information about the contents of theses accepted in British universities and increasing their availability. A report by this sub-committee, published in the *Library Association Record* (60, 13; 1958), expresses the opinion that the arrangements with regard to theses are generally too haphazard to be entirely satisfactory and that it should be possible for the universities to adopt a uniform plan to render such information more comprehensive and regularly available. The sub-committee was aware of the "Index to Theses accepted for Higher Degrees", published annually by Aslib since 1950–51, and noted a scheme operated by University Microfilms in the United States in which some eighty universities and associated institutions participate, but inquiries as to the feasibility of a similar scheme in the United Kingdom met with a disappointing response. The report summarizes the difficulties which must be overcome in regard to accessibility or secrecy, copyright, etc. It stresses the importance both of the Standing Conference of National and University Libraries persuading British universities to accept a desirable standard of availability and also of the work of the Department of Scientific and Industrial

Research in improving communication between the universities and government research establishments. A new commercial but selective scheme for microfilming dissertations is briefly described, which could be adapted to meet the requirements of individual universities and eliminates the need to charge a microfilming fee.

Computer Training Centre

BRADENHAM MANOR, the property of the National Trust, has been leased to the British Tabulating Machine Co., Ltd., for use as a Hollerith Computer Training Centre. On July 24 the Centre was opened by Lord Halsbury, managing director of the National Research Development Council, who said that the old idea that a trainee learnt his job by copying what his predecessor could be seen to be doing has no room in the field of computer training. Training on modern, almost academic, lines is what is required and such training the Bradenham centre would provide. Some 3,000 people per annum undergo training in the use and applications of mechanized accounting equipment at the five educational and training establishments maintained by the British Tabulating Machine Company's resources. Other facilities will become available as the result of the proposed merger with Powers-Samas.

Rugby School Natural History Society

P. R. M. Pattisson, a scholar at Rugby, has carried out experiments to determine the reactions of *Gammarus* sp. to water currents. The apparatus consisted of a double horseshoe-shaped trough about 7 ft. long, containing water circulated by a paddle-wheel. The water was about ½ in. deep. The speed just above the bottom was measured by timing the movement of a small piece of pumice-stone weighted with 'Plasticene' over a measured distance. Experiments were carried out in the clear straight side of the trough which was marked off in inches and showed that the swimming speed increases linearly with the current. While swimming, *Gammarus* is able to gain ground for any current speed. The rate of increase in swimming speed is less than the corresponding increase in current; the animal gains ground more slowly at the higher current speeds. The respiration of *Tubifex* and *Culex* sp. has been investigated by A. M. Roberts, another scholar at Rugby. The Report for 1957 (Report of the Rugby School Natural History Society for the year 1957. Pp. 28+1 plate. (Ninety-first issue.) Rugby: Rugby School Natural History Society, 1958) contains details of these two investigations as well as reports of all the many sections affiliated to the Society. Their activities do credit to scholars and staff.

Circulation in the Black Sea

IT is usually assumed that the Black Sea in its deeper part (below 200 m.) consists of stagnant fœtid waters rich in hydrogen sulphide. This led to a suggestion that the Black Sea may be utilized as a depository for the atomic waste. Arguments showing the erroneous conception of 'buried' bottom waters of the Black Sea are brought forward by V. A. Vodyanitzky (*Priroda*, 2, 46; 1958), who presents strong evidence in favour of the existence of convexion currents producing a vertical circulation of the waters of the Black Sea.

Geological Age

EDUARD SUESS in his "Face of the Earth" postulated the existence of "the most ancient vertex of the Eurasian folds" occupying the mountain-crescent fringing Lake Baikal in the south. This vertex, formed by folded mountains of the Pre-Cambrian age, fringes the southern border of the stable "Augara Land'. As outlined by V. T. Mordovsky (*Priroda*, 3, 85; 1958), this conception, based on the original works of I. D. Chersky and V. A. Obruchev, must be completely reconsidered in the light of subsequent interpretations carried out by L. de Launay, M. M. Tetiaev, A. N. Churakov and N. S. Shatsky. According to the Tectonic Map of the U.S.S.R. edited by Shatsky and published in 1957, the exposed portions of the Pre-Cambrian 'Augara Land' are exposed only in the Anabar, Sayan and Aldan massifs, while its remaining parts are covered by later stratified unfolded deposits. At the same time, the greater part of the area of the alleged "ancient vertex" must be considered to be formed by rocks folded during the Baikalian orogenesis (Early Cambrian to late Proterozoic) and Caledonian orogenesis (late Palæozoic). "Thus", writes Mordovsky, "the ancient vertex of Asia, as understood by Chersky, Obruchev and Suess, does not exist. The Siberian Platform, together with the Anabar massif and the Aldan shield, is one of the most ancient areas in the northern Asia".

Root–Shoot Relationships

THE effect of removing part of the root system on the subsequent growth of the root and shoot systems has been investigated by E. C. Humphries (*Annals of Botany*, N.S., 22, 251; 1958). When some 50 per cent of the roots of barley and rye were removed, the growth-rate of the remaining roots was the same in intact plants; but the growth-rate of the shoot decreased progressively as more and more roots were removed. When the number of roots removed exceeded 50 per cent, there was a decline in the rate of root growth, though this was less marked than that of the shoot. Comparable results were obtained in experiments in which the lateral roots of tomatoes were removed; but in this species a 40 per cent removal of laterals was critical for maintenance of growth in the remaining root system. The author also reports that the uptake of potassium, in barley plants with parts of the root system removed, was closely proportional to the increase in dry-matter when the nutrient supply is not limiting; but, with low nutrient supply, the potassium uptake was less than the dry-matter increase.

Auxins in Bean Embryo Development

M. Furuya and K. Soma have contributed some interesting new observations on the effects of various auxins on the development of bean (*Phaseolus vulgaris*) embryos grown *in vitro* (*J. Fac. Sci. Univ. Tokyo*, Sect. 3, 7, 163; 1957). Dormant embryos were removed from the cotyledons and cultured either intact, or as four separate regions or segments, namely, the apical portion, including the first foliage leaves, the hypocotyl, the short basal transitional region, and the radicle. White's solution, with the vitamins omitted, was used, together with individual additions of β-indolylacetic acid, sodium 2,4-dichlorophenoxyacetate (2,4-D) and sodium α-naphthylacetate at different concentrations (10^{-3}–10^{-11} mole

per litre). Liquid and solid media were both used and cultures were maintained either in continuous darkness or in 12 hr. of light a day. Measurements of growth and of morphological and histological developments are recorded and illustrated. Among the abnormal developments observed, especially at the higher concentrations of auxin, were the formation of tumourous and callus tissues, disorganizations of normal tissue differentiation, and formation of adventitious roots, but no induction of buds is reported. Attention is directed to the different reactivities of different regions of the embryo according to concentration of auxin and cultural conditions. The three auxins tested had generally comparable effects on the growth and differentiation of embryos, namely: complete inhibition of growth; inhibition in meristematic tissues, including the procambium, but extensive activation in mature tissues; activation in meristematic tissues, including the formation of adventitious roots; and regulation of growth-rate, these being in the order of decreasing auxin concentration. The results obtained are discussed fully in relation to contemporary views on auxin action.

Control of Dollar Spot Disease (*Sclerotinia homoeocarpa*)

Trial work with a new fungicide, cadmium chloride/urea, has recently been completed by the Sports Turf Research Institute (*Sports Turf Bulletin*, 41, April–June, 1958) for the control of dollar spot disease. Outstanding results were obtained from seven (monthly) applications of the fungicide on the bowling green of the Briton Ferry Steel Co., Ltd., in Glamorgan. The green (originally of sea-marsh origin) still contains a proportion of the original sea-side bents and fescues with an admixture of annual meadow grass. Although in good condition each summer, the fescue has been progressively weakened by attacks of dollar spot disease. Work with the cadmium chloride/urea fungicide started in April 1957. Further applications at the same rate were made in May, June, July, August, September and October. The fungicide spray was combined with the regular application of fertilizer—three evenly spaced applications of fertilizers containing a high proportion of readily available nitrogen. When examined in November, the turf was found to be free from visible signs of the dollar spot disease. There were no signs of other diseases such as *Fusarium* patch and *Corticum*. The same fungicide was effective in controlling dollar spot disease on bowling greens in Yorkshire and Lancashire. On other greens good control of the disease has been obtained, but where an insufficient number of applications has been made, the disease has re-appeared later.

Colour Changes in Teleosts

The control of colour changes in the lower vertebrates, including the teleostean fishes, has received a considerable amount of attention, and various different and even conflicting theories have been put forward to explain it. In a recent study, Priscilla Rasquin (*Bull. Amer. Mus. Nat. Hist.*, 115; 1958) has approached the problem from a different aspect and, instead of studying one or two species in detail, has surveyed a wider field. The memoir is divided into two separate parts. Part 1 is the study of the histomorphology of the pineal complex of thirty-three species of teleosts, including freshwater and marine forms. In general, the extent of the specialization of the pineal organ (epiphysis) is related to the degree of transparency of the overlying tissues and it exhibits a wide range of variation. Experiments on pinealectomy in *Astyanax* show no appreciable effect upon pigmentation, and while there is some evidence of secretory activity in the pineal organ in some species there is none of an endocrine function. Part 2 is a study of the effects of the injection of adrenalin in thirty-five different species and also of intermedin and a series of mammalian pituitary hormones. With adrenalin three groups can be distinguished in which there is: (1) a concentration of granules in the melanophores; (2) a concentration in the internal melanophores only; (3) no effect. In all species there was a response in the lipophores to adrenalin but in one group the response was dispersion and in the other concentration of the pigment granules. With intermedin all species showed dispersion in the lipophores, but the melanin granules in the chromatophores in four species showed concentration and others gave no reaction. These observations show the need for further investigation, for the responses in one species need not be duplicated in another, and it is dangerous to argue from the particular to the general. Some of the photomicrographs in the ten plates are not good, and most would be more useful if labelled.

Continuous-writing Streak Camera

An improved streak camera for the study of fast self-luminous events has been developed by Beckman and Whitley. It is intended primarily for the study of explosions, shock tube, spark discharge and similar phenomena. Standard 35-mm. film, arranged for daylight loading and unloading, is used. The image is swept on to this film by a rotating triangular mirror driven by a high-speed turbine. Several types of these are available—the fastest one, ranging from 200 to 5,500 revolutions per second, is driven by helium gas. This arrangement produces a maximum writing rate of approximately 8 mm./μsec.; and a maximum time resolution, using a 0·004-in. wide slit image and film having a resolution of 75 lines per mm., of $2{\cdot}5 \times 10^{-8}$. The camera has a control equipment which includes an events-per-unit-time meter for accurate measurement of the mirror speed to provide a determination of writing-rate; mirror-speed adjustments; and controls for the capping shutter and the explosive-actuated blast shutter, used to prevent rewriting in the case of events of long duration.

Cometary Spectra

In a recent paper entitled "Molecules in the Solar System" (*Cont. Dominion Astrophys. Obs., Victoria, B.C.*, No. 51), A. McKellar discusses gaseous molecules in comets and in planetary atmospheres, including that of the Earth. The spectra of comets are characterized by the occurrence of emission bands of molecules superposed on a background of reflected solar radiation. The spectra of comets are generally solar when their heliocentric distances exceed 3 astronomical units, but emission bands appear as the comet approaches the Sun. Generally speaking, heliocentric distance has proved the most useful parameter in describing the behaviour of the molecular emissions.

Dealing with the source of cometary gases, reference is made to Whipple's cometry model (*Astrophys. J.*, 111, 375; 1950, and 113, 464; 1951), which envisages the nucleus as a conglomeration of frozen solids, such as water, ammonia, methane, carbon dioxide or carbon monoxide, and possibly other materials, combined with meteoric matter, all initially at a temperature below 50° K. As the comet approaches the Sun, the frozen solids vaporize and so provide the parent molecules which, upon photo-dissociation, give the radicals the spectra of which we observe. Donn and Urey have suggested a modification of Whipple's model (*Astrophys. J.*, **123**, 339; 1956) to include both stable and reactive molecules, yielding radicals which could lead to actual chemical explosions to explain observed cometary activity. They give examples of a number of laboratory experiments involving NH and azides, OH and hydrogen peroxide, etc., that could conceivably occur if concentration of the necessary radicals and other molecules were present in the matrix. It appears, therefore, that solar radiation or corpuscles need only act as a trigger for the strongly exothermic reactions which provide their own excess of energy in the explosion.

Proceedings of the Royal Institution

THE *Proceedings of the Royal Institution* are to be published three times a year in future instead of annually; one advantage of the new procedure will be that the discourses will appear in print soon after their delivery. Thus, Vol. 37, Part 1, No. 165, which is the first to appear under the new arrangement, opens with the discourse on gemstones given by Sir Lawrence Bragg on January 31, 1958, and includes five other discourses given before Easter. It is also intended to publish once a year a famous discourse given at the Royal Institution a hundred years ago. The *Proceedings* are available to non-members at 8*s*. 6*d*. per issue, or 21*s*. a year, from January 1, 1959 (from the Royal Institution, 21 Albemarle Street, London, W.1).

"Rejection of the Peroxide Accumulation Hypothesis of Isoniazid Action"

DR. FRANK WINDER, Laboratories of the Medical Research Council of Ireland, Trinity College, Dublin, writes: "In a communication under this title in *Nature* of April 26, p. 1203, Holmes and Rubbo state that 'Sodium nitrite . . . reduces free peroxide, and reacts rapidly with the catalase–peroxide complex . . .'. The first portion of this statement is true only when the *p*H is well on the acid side. To check this, 50 μgm. per ml. hydrogen peroxide were incubated with 500 μgm. per ml. sodium nitrite for 24 hr. in phosphate buffers over the *p*H range 5–7. The peroxide was then estimated by methods which did not involve acidification, for example, by using peroxidase or luminol. The nitrite caused no significant destruction of the peroxide in any of these buffers".

The Night Sky in September

NEW moon occurs on Sept. 13d. 12h. 02m. U.T., and full moon on Sept. 27d. 21h. 43m. The following conjunctions with the Moon take place: Sept. 4d. 21h., Mars 0·5° N.; Sept. 16d. 07h., Jupiter 0·2° N.; Sept. 19d. 15h., Saturn 3° S. In addition to these conjunctions with the Moon, Mercury is in conjunction with Venus on Sept. 5d. 02h., Mercury being 2·1° S., Venus with Regulus on Sept. 8d. 17h., Venus being 0·7° N., Mercury with Regulus on Sept. 10d. 09h., Mercury being 0·0° N., and Mercury with Venus on Sept. 18d. 06h., Mercury being 0·3° N. Mercury is favourably placed for observation during the first fortnight of the month, and is a morning star, rising at about 4h.; during this period its stellar magnitude increases from +1·6 to −0·7. Venus is also a morning star, visible low in the south-east before sunrise. It rises at 3h. 30m., 4h. 10m. and 5h. 0m. on September 1, 15 and 30, respectively; its stellar magnitude is −3·3. During the month its distance from the Earth increases from 149 to 156 million miles and the visible portion of the apparent disk from 0·947 to 0·982. Conditions for observation are rather unfavourable at the end of the month. Mars rises at 21h. 20m., 20h. 35m. and 19h. 45m. at the beginning, middle and end of the month, respectively. Its stellar magnitude increases during the month from −0·5 to −1·1, its distance from the Earth decreasing from 70 to 56 million miles. Mars enters Taurus on September 1, and continues moving eastwards among the stars; it is south of the Pleiades on September 13–16. Jupiter is too close to the Sun for satisfactory observation. Saturn sets at 22h. 30m., 21h. 35m. and 20h. 40m. at the beginning, middle and end of the month, respectively; it is near θ Ophiuchi. It has a stellar magnitude of +0·7 and a distance of 935 million miles from the Earth on September 15. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Sept. 7d. 01h. 46·6m., 115 Tau. (*R*); Sept. 9d. 02h. 12·8m., λ Gem. (*D*); Sept. 9d. 03h. 02·0m., λ Gem. (*R*); Sept. 21d. 19h. 08·9m., ρ Sgr. (*D*); Sept. 22d. 23h. 18·2m., β Cap. (*D*). *R* and *D* refer to reappearance and disappearance, respectively. The autumnal equinox occurs on Sept. 23d. 13h.

Announcements

THE nineteenth national conference of the Council for the Preservation of Rural England, on "Rural Problems of the Moment", will be held in Cheltenham during October 16–18. Further information can be obtained from the Secretary of the Council, 4 Hobart Place, London, S.W.1.

THE first electronic computer exhibition in Europe will be held at Olympia, London, during November 28–December 4. A business computer symposium will be held concurrently. Further information can be obtained from Mrs. S. S. Elliott, 11/13 Dowgate Hill, London, E.C.4.

THE Institute of Physics, one of the constituent bodies of the British Nuclear Energy Conference, is arranging a Symposium in London on "Nuclear Fuel Cycles", on January 22 and 23, 1959. The papers which have been invited cater mainly for those working in the field, and will deal with the applied physics aspects of the fuel cycles which form the basis of the immediate nuclear power programme. Application to attend the Symposium should be made to the Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1. Proceedings of the Symposium will be published in the *Journal of the British Nuclear Energy Conference*.

COLONIAL TERRITORIES

THE report on the Colonial Territories for 1957–58* provides the usual conspectus of political, economic, financial and social developments in these territories against which the achievements to be recorded in greater detail in "Colonial Research, 1957–58" are to be considered. Some of this material, outlined in the 22-page chapter entitled "Research and Surveys", has also appeared in reports from various Colonial research organizations already noted in *Nature*, and for this reason, while this chapter in the present report is the one of most direct interest to the scientist, consideration of research in the Colonial territories is deferred until the fuller report, "Colonial Research, 1957–58", is published in due course.

Recruitment through the Colonial Office continued at the same general level as last year, but recruitment for the Federation of Malaya was gradually transferred to the High Commissioner for that territory. About the same number of administrative and medical officers were appointed as in 1956, but the number of educational appointments increased and the number of civil, mechanical and electrical engineers and agricultural officers recruited decreased. The total overseas appointments through the Colonial Office was 1,296 as compared with 1,286 in 1956, leaving 1,385 unfilled vacancies at the end of 1957, compared with 1,461 at the end of 1956. Training courses and attachments were arranged for 2,925 men and women in the service of overseas governments, compared with 2,752 in 1956.

The recession in world commodity prices in 1957 had little effect on the territories, and taking the year as a whole the prices of most Colonial products, except copper and sisal, were as high or higher than in 1956. Output continued to rise and the total gross domestic product is estimated as some 4 per cent above the 1956 level of about £3,100 million, the greatest proportionate increase being in the West Indian territories, where the value of exports rose by 12 per cent compared with a general increase of 2 per cent. The volume of exports of primary products rose only slightly.

After two years experimental work in the Western Region of Nigeria, 2,000 farmers were trained in their villages in spraying against capsid pest of cocoa. The extensive spraying campaign against blackpod continues, but control of swollen shoot disease has lost ground. Farmer-training in the control of blackpod and capsid on cocoa continued in the Eastern Region and about one-third of the 8,000 cocoa farmers in the Southern Cameroons sprayed their cocoa against blackpod disease with excellent results. In Kenya use of parathion sprayed from aircraft at night showed great promise for control of infestation by the Quelea bird (Sudan Dioch), and use of dieldrin for control of white stem borer of coffee and of DDT/BHC dust for cotton pests continued to spread in Tanganyika. A programme of research and control of the serious incidence of insect pests of cotton in the Aden Protectorate is in progress. Research continued into the most suitable types of fertilizers for individual soils and crops, and use of fertilizers continued to increase. The territories continued to receive expert assistance under the Expanded Technical Aid Programme. Two teams of experts visited Jamaica, Trinidad, British Honduras and Dominica to survey costing methods and research needs, respectively, of the citrus industries.

Effective control of the major epizootic diseases continued in the West African territories, but trypanosomiasis continues to be a serious problem in East and Central Africa.

Public expenditure on development continued at a high rate and expenditure from Colonial Development and Welfare Funds rose by about £1 million, but was still only about three-quarters of the annual average available under the 1955 Colonial Development and Welfare Act. New development plans were drawn up in Jamaica and Trinidad, and during the year power supplies became available for Kenya from the Owens Falls hydro-electric plant in Uganda. A new road from Western Uganda to the Belgian Congo was completed, work begun on the construction of a deep-water harbour in Barbados and the first hydro-electric plant in British Guiana came into operation.

Facilities for education increased in nearly every territory, as did the numbers using them. Of the 3,400 students in the two universities and three university colleges, 1,075 were in the University of Hong Kong, 749 at University College, Ibadan, 710 at the University College of East Africa, Makerere College, and 566 at the University College of the West Indies. Teaching and administrative staffs have also expanded, and University College, Ibadan, has now a fully established medical school with a new teaching hospital. In co-operation with the Nigerian College of Arts, Science and Technology, which was formally opened in November, a faculty of engineering is being established, and the University College of the West Indies is considering the establishment of a faculty of agriculture. Allocations to these university institutions under the Colonial Development and Welfare Funds for capital expenditure for the 1955–60 quinquennium total £6,853,000. The Royal University of Malta was the subject of an investigation by a Royal Commission, and the Governments of Kenya, Uganda, Tanganyika and Zanzibar jointly published a paper outlining their future plans for higher education.

Progress in preventive and social medicine has been in two main directions: by a widely developed attack on communicable disease by mass campaigns of treatment, immunization or destruction of insect vectors; and by much greater attention to the needs of the family and the individual through the medium of health centres, specialized clinics and an elaboration of domiciliary care. Control and ultimate elimination of malaria still constitute a major challenge, but the effects of a more enlightened outlook on leprosy are apparent in the recognition of the need for social rehabilitation of those cured.

Of the 9,923 Colonial students in the United Kingdom and the Irish Republic at the end of 1957, 1,298 held scholarships and 2,709 were at universities. Of the total, 3,360 were from West Africa and 3,096 from the West Indies; 867 were studying engineering, 745 medicine, 308 science, 228 economics, 89 agriculture and 69 dentistry. Tribute is again paid, here

* Colonial Office. The Colonial Territories 1957–1958. Pp. xxv+171. (Cmnd. 451.) (London: H.M. Stationery Office, 1958.) 9s. net.

and in respect of information services, to the work of the British Council. It is estimated that 1,033,000 U.S. dollars will be spent on the United Nations Expanded Programme of Technical Assistance in the British territories in 1958 compared with 1,271,000 dollars in 1957. Under the Fulbright Agreement nine American teachers were posted to schools in Western Nigeria, St. Helena, Antigua, Grenada, Jamaica and Montserrat, and nine senior research workers attached to university and research institutions in East Africa, Northern Nigeria, Hong Kong, Jamaica and Trinidad, while two scientists continued research into the preservation of wild life in the game reserves of Uganda. Travel grants enabled lecturers from University College, Ibadan, the University College of the West Indies and the University of Malaya to visit the United States for research and to give lectures. An Overseas Visual Aid Centre has been established in London with the joint support of the Government and the Nuffield Foundation to further the use of visual and audio-visual aids in education.

SOLID STATE PHYSICS

CONFERENCE IN BRUSSELS

As part of the activities associated with the Brussels Universal Exhibition, a Conference on Solid State Physics and its applications to electronics and telecommunications was held in Brussels during June 2–7. The meeting had the patronage of the King of the Belgians and the support of the International Union of Pure and Applied Physics. It was regarded as appropriate because of the stress laid by many exhibitors on contemporary scientific achievements. After an introductory lecture by W. Shockley, the 750 participants from twenty-four countries divided up to listen to papers which were grouped in five parallel sessions throughout the six days of the conference.

It was inevitable that such a meeting would be dominated by discussions of the properties of semiconductors, their theory, and the main applications in transistors, phosphors and electroluminescence. There were also sessions on ferrites. Despite the extent of the field covered, its unity, so far as basic ideas are concerned, became very clear as the meeting progressed. This proved to be a stimulus to many participants, who regretted the large number of papers offered rather than the spread of topics.

The areas of activity in the field of pure semiconductors include equilibrium properties such as susceptibility measurements, transport phenomena, the study of barrier layers and surfaces, of noise, life-times and recombination, optical properties, the growth of, and imperfections in, single crystals, and the changes induced by irradiation. All these topics, and others on the more applied side, were discussed at this meeting, as they were at the last similarly international meeting at Garmisch in 1956 (see *Nature*, **198**, 1156; 1956). A slight change of emphasis has, of course, occurred. For example, at Garmisch considerable interest was shown in the newly discovered phonon drag effect, which implies, for example, that long wave-length phonons exert a drag on the charge carriers, and contribute rather strongly to thermal conduction. Little was said about this effect in Brussels. On the other hand, the properties of electrons which are not in equilibrium with the lattice owing to the effects of an applied electric field—the so-called 'hot electrons'—received much more attention than they did at Garmisch, and this promises to remain an active field.

For example, J. Bok (École Normale Supérieure, Paris) reported attempts by thermionic emission experiments to obtain direct evidence of the temperature of hot electrons. S. H. Koenig (I. B. M. Watson Laboratories, Columbia University) emphasized again that the hot electron distribution function responds very rapidly (within less than 10^{-9} sec.) to changes in the applied field. In many aspects of these effects theory still lags behind experiment. This became particularly clear from a talk by R. Stratton (Metropolitan-Vickers Electrical Co., Manchester), who discussed theories of the dependence of electron mobilities on the electric field.

As the applied field is increased, the hole and electron temperature rise, and in due course breakdown occurs. In p–n junctions the breakdown is believed to be of the avalanche type. This was discussed for germanium by B. M. Wul (Lebedew Institute, Moscow). He showed that the coefficient of impact ionization for holes is about twice that for electrons. Recent work for silicon (Chynoweth, A. G., *Phys. Rev.*, **109**, 1537; 1958) is of interest here for comparison. The properties of hot electrons may also be expected to affect the current – voltage relation of p–n junctions for high forward currents. This was discussed by A. K. Jonscher (General Electric Co., Wembley), the suggested form of the relation being $I^{1/2} = AV(V - B)$.

In this field of barrier-layer physics, attention was directed by several speakers to the measurement of the working temperature in the barrier (which has a pronounced effect on the properties of silicon and germanium rectifiers). Considerable interest was also shown in narrow germanium p–n junctions containing high concentrations (10^{18} to 10^{20} cm.$^{-3}$) of impurities. In such structures the Fermi-level can lie below the top of the valence band on one side, and above the bottom of the conduction band on the other side. This gives rise to stability against thermal shock, and to a forward current-voltage characteristic which exhibits negative resistance (for preliminary results, see Esaki, L. (Tokyo), *Phys. Rev.*, **109**, 603; 1958). An incidental point of interest is that the direction of rectification is opposite to the usual one, and so is in agreement with that suggested in 1932 on the hypothesis of electron tunnelling.

It appears that semiconductor surfaces are being investigated increasingly by means of adsorption characteristics. The possibility of either mobile or localized adsorbed films of various kinds on germanium surfaces was envisaged by M. J. Sparnaay (Philips Research Laboratories, Eindhoven), and by H. Statz (Raytheon Co., Waltham, Mass.). Low-energy electron diffraction and work-function measurements were used by H. E. Farnsworth *et al.* (Brown University, Rhode Island) to study the structure and adsorption characteristics of clean germanium surfaces. He showed that surface atoms, displaced on a clean surface, appear to be restored to

their normal positions by the presence of a chemisorbed oxygen monolayer. The effect of oxygen adsorption on the photoelectric sensitivity of bismuth films was discussed by R. Suhrmann (Hannover).

An interesting group of papers on silicon was submitted from the British Associated Electrical Industries group of companies. R. C. Newman and J. Wakefield (A.E.I. Laboratory, Aldermaston) pointed out the possibility of a connexion between the formation on silicon surfaces of etch pits on one hand and of silicon carbide on the other. The distribution of impurities in pulled silicon crystals was discussed, among other topics, in two papers (N. R. Howard; P. Ransom, British Thomson-Houston Co., Rugby). H. F. Mataré (Sylvania Electric Products, Inc., Bayside, N.Y.) reported electrical experiments on bicrystals having known angles of misfit, and drew conclusions about the overlap of wave-functions of dangling bonds which occur at grain boundaries. Further information about these effects was expected at the meeting being held at Rochester, New York, at which a session is being devoted to grain boundaries and dislocations. An interesting aspect of crystal imperfections is their effect on mechanical damping. In silicon and germanium single crystals the damping usually shows two peaks when regarded as a function of temperature. The low-temperature peak at about two-thirds the melting point may perhaps be associated with the movement of dislocations. The high-temperature peak is probably connected with the motion of dissolved oxygen. A paper on these effects was read by P. D. Southgate (Mullard Laboratories, Salford).

Because of their applications to thermoelectric refrigeration a session was devoted to tellurides. The theory of remanent magnetization, important in connexion with magnetic recording tapes, was discussed by E. P. Wohlfarth (Imperial College of Science and Technology, London). Other applications which were considered included the use of impact ionization of impurities for low-temperature computing elements, applications of fluorescence to post office sorting problems, and several papers on transistor technology. As in the case of the earlier meeting at Garmisch, band calculations were discussed only incidentally. Impurity band conduction was mentioned somewhat more prominently—for example, in some speculations about the transition to metallic impurity band conductivity. The apparent absence of impurity band conduction down to 2° K. in some specimens of InSb was pointed out by E. H. Putley (Royal Radar Establishment, Malvern).

Other stimulating contributions, for example, in magneto-optics, are not mentioned here, since they are included in other conferences this summer. The proceedings of the Brussels meeting have been promised for the end of this year. Those of the 1956 Garmisch meeting are still expected.

P. T. Landsberg

STERIC EFFECTS IN CONJUGATED SYSTEMS

THE consequences of steric interactions in organic molecules are of wide practical and theoretical interest to chemists, but the entire field of steric effects in organic chemistry is too vast to be covered in one conference. "Steric Effects in Conjugated Systems" was therefore chosen as the title for the Chemical Society symposium, held in Hull during July 15–17, because this topic is still of wide appeal to chemists and yet is sufficiently specialized to be treated in considerable detail by some fifteen papers, dealing with the study of steric effects by spectroscopic, kinetic, and other physical methods.

The introductory paper was read by Prof. E. E. Turner (Bedford College, London). He traced the chemical developments which led away from the Kaufler formula for diphenyl to the concept of a molecule comprised of two collinear benzene nuclei which will tend to be planar. This structure allowed an explanation of the optical isomerism of suitable diphenyls carrying four, three, two, or even one substituent in the sterically sensitive *ortho*-positions. This marked the discovery of molecular dissymmetry arising from restricted rotation about a bond—one of the most important steric effects which may arise in a conjugated system—and led to more recent work on 2 : 2′-bridged diphenyls. The conformational stabilities and molecular configurations for compounds containing two or more atoms in the bridge are now being studied by ultra-violet absorption spectroscopy.

Steric effects in diphenyl were also treated by Dr. G. H. Beaven (National Institute for Medical Research), who discussed the ultra-violet absorption spectra of pure alkyldiphenyls. While a 4-methyl substituent gives a red shift and an intensity increase of the conjugation band, 2-methyl substitution gives a blue shift and an intensity decrease. Further methyl substitution in the *ortho*-positions increases this effect, and the results are consistent with the hypothesis that progressive introduction of methyl groups into these positions gives progressive deviation from coplanarity and decrease in conjugation. Higher alkyl groups, unless branched, do not increase the steric effect, and the spectrum of 2 : 2′-dimethyldiphenyl suggests that the molecule has the *cis*-configuration already reported for 2 : 2′-dihalogenodiphenyls. The vapour-phase chromatography of these alkyldiphenyls was discussed by Dr. E. A. Johnson (National Institute for Medical Research), who has shown that the retention volumes for a single stationary phase depend on the position of the alkyl groups. Thus, 2-alkyldiphenyls have smaller retention volumes than the 3- or 4-isomers, presumably because the lower conjugation in the 2-isomer gives rise to less interaction with the stationary phase. The results confirm the conclusions reached from ultra-violet spectra relating conjugation to position and number of alkyl groups, and it has been possible to identify the peaks of a gas–liquid chromatogram of 21 isomeric tetramethyldiphenyls. Conjugation in 2 : 2′-bridged diphenyls and in halogenodiphenyls was also discussed in the light of the relative retention volumes for the compounds.

The influence of steric interactions upon the mesomorphic behaviour of 4-*p*-*n*-alkoxybenzylideneaminodiphenyls and 4 : 4′-di-(*p*-*n*-alkoxybenzylideneamino) diphenyls was discussed by Dr. G. W. Gray (University of Hull). A 2- or 2′-substituent in the diphenyl

nucleus decreases the mesomorphic thermal stability more than a 3- or 3′-substituent. Clearly, twisting about the 1 : 1′-bond interferes with the molecular packing in the mesophases, and indeed increasing size of halogen increases the effect. A methyl group appears to have about the same steric effect as a chlorine, and 2 : 2′-disubstituted derivatives appear to adopt a *cis*-configuration. It is difficult to assess the configuration of the unsubstituted diphenyl ring system in the mesophases, but the results suggest that it may be planar.

Prof. C. A. Coulson (University of Oxford) described the use of molecular-orbital theory to explain the observed blue wave-length shifts in the ultra-violet spectra of diphenyls when the molecule is twisted about the 1 : 1′-bond. Reference was made to an alternative procedure developed by Longuet-Higgins and Murrell for such a system *A*–*B* (*A* and *B* may be groups such as phenyl, nitro-, etc.), and this was thought to be of promise for dealing with nitro-anilines, where a full self-consistent-field molecular-orbital calculation would be complex. Relief of steric strain by displacement was then discussed by reference to the idealized case of a benzene ring folded through an angle about the 1 : 4-axis. The method of using mean resonance integrals was applied to this condition, which is similar to that occurring in the *paracyclo*phane series, and used to explain the observed bathochromic shifts in these compounds. The same method was used to deal with 3 : 4-benzphenanthrene which on 5- and 4′-methylation gives a progressive red shift which must be due to steric strain. The calculated effective resonance integrals for the mono- and di-methyl compounds agree excellently with those derived from spectra, and, moreover, the observed methyl affinities and the calculated free valences of the hydrocarbon agree well. The technique of using an average resonance integral is safest for such large polynuclear molecules where the strain is uniformly distributed throughout the molecule.

The contribution of Prof. M. J. S. Dewar (Queen Mary College, London) on the light absorption of cyanine dyes also concerned the direction of wave-length displacements arising from deviations from coplanarity. Hypsochromic displacements occur in the unsymmetrical cyanines, but the more unusual bathochromic shifts are observed in symmetrical cases. Prof. Dewar criticized explanations of these effects based on resonance theory, and applied molecular-orbital theory to the problem. While the strain of small distortions may be taken up by twisting about the central bonds in the dye, it is possible that large strains cause distortion of the whole molecule—buckling of rings—and this would lead to bathochromic shifts. Prof. Dewar considered that a more detailed treatment of this kind would be useful.

Steric effects in dyes again featured in the paper by Dr. C. C. Barker (University of Hull) on basic di- and tri-phenylmethane dyes. When the three main types of basic dye—Michler's hydrol blue, malachite green and crystal violet—are substituted, the molecular conformation and the electronic absorption spectra are usually modified, and Dr. Barker related the direction and extent of observed wave-length shifts to the steric and conjugative effects of the substituents. Alkyl derivatives of the three main types were fully discussed, and with malachite green the effects of numerous substituents in the phenyl ring were determined for comparison with the effects of substitution in the dimethylaminophenyl rings.

To the two classes of steric effect in ultra-violet absorption spectra proposed by Braude—steric interactions causing changes in (1) intensity only and (2) both wave-length and intensity—Prof. W. F. Forbes (Memorial University of Newfoundland) adds a third, covering steric interactions which so inhibit conjugation that the system absorbs as two entities. The mechanisms underlying the different types were discussed, although, in the absence of planar reference compounds, the identification of the type of effect may be difficult. Prof. Forbes illustrated the effect of both substituent size and nature of solvent upon the type of steric effect, and mentioned developments to which adoption of the classification may lead.

Dr. E. S. Waight (Imperial College of Science and Technology, London) concluded from measurements of the ultra-violet absorption spectra of conjugated carbonyl compounds at 20° and −196° that type I steric effects cannot be associated with transitions from non-planar ground-states to near planar excited states. From the infra-red and ultra-violet spectra of αβ-unsaturated carbonyl compounds, it is concluded that 2-methyl-1-acetyl*cyclo*hexane has an *s-cis*-structure, which is not planar. Using the ideas of Longuet-Higgins and Murrell on electronic transitions in the system C=C—C=O, it is thought that steric hindrance to planarity will produce Braude's type I effect when the transition is to an electron transfer state, and to a type II effect when the transition involves locally excited states.

Steric effects in monomethyl 1 : 2-benzanthracenes were discussed by Dr. G. Dallinga (Shell Laboratories, Amsterdam). The basicity constants and rates of H–D exchange for the twelve methyl isomers correspond strictly, but the observed basicities can be discussed in terms of the methyl group's inductive effect only when steric effects do not operate. Steric effects must therefore influence both the basicities and the rates of exchange for these isomers, and it is proposed that the structure for the transition state for the exchange resembles that of the conjugate acid. To explain the enhanced basicity of the 9-carbon atom, a steric repulsion is proposed between the hydrogens on the 9- and 1′-carbon atoms.

The influence of *ortho*-substituents upon the reactivities of groups in aromatic molecules has been extensively studied, since the Hammett equation is useful only in correlating reactivities in *meta*- or *para*-substituted systems, where there is no steric effect. Mr. A. C. Farthing and Mr. B. Nam (Imperial Chemical Industries, Ltd.) have derived a four-parameter, modified Hammett equation for *ortho*-substituted systems:

$$\Delta \log K = \sigma_S \rho_S + \sigma_E \rho_E$$

A graphical test ($\Delta \log K/\sigma_S$ against σ_E/σ_S) for forty-five reactions in the literature gives a correlation which is good enough to warrant statistical analysis and which suggests that the equation has some empirical validity.

In electrophilic aromatic substitution or side-chain reactions involving an electron-deficient centre, strong resonance interactions occur between the centre and the substituent. Such interactions are unimportant in the ionization of benzoic acids from which Hammett substituent constants are derived, and the constants cannot be used to treat the above reactions. Prof. H. C. Brown (Purdue University, Indiana) seeks to extend the Hammett treatment to

these exceptional systems by obtaining substituent constants incorporating such resonance interactions from the rates of solvolysis of phenyldimethylcarbinyl chlorides. These electrophilic substituent constants have proved useful in quantitatively correlating directive effects in electrophilic aromatic substitution reactions, but a theoretical basis is required for the empirical correlations.

A review of steric effects in nucleophilic aromatic substitution by Prof. N. B. Chapman (University of Hull) covered both primary kinetic steric effects—steric retardation or acceleration of reactions—and secondary steric effects—steric inhibition of mesomerism. Examples of these effects, many from Prof. Chapman's work on nucleophilic aromatic substitution, were given. Although steric acceleration of a reaction is rarer than retardation, the effect is often large when it occurs, for example, in the Smiles rearrangement of 2-hydroxy-2′-nitrodiphenyl sulphone to 2-*o*-nitrophenoxybenzenesulphinic acid. The difficulties in reaching mechanistic interpretations of primary kinetic steric effects were discussed, and attention paid to the influence of the size of the attacking nucleophilic reagent.

Dr. B. M. Wepster (University of Delft) illustrated how the careful interpretation of electronic absorption spectra can lead to a better understanding of chemical data. Thus, the linear relationship between the conjugation band intensities in the ultra-violet spectra and the ΔpK_a values for the *p*-nitroanilines confirms that the inductive and mesomeric effects of the nitro-group operate almost equally in these molecules. The absorption spectra data for nuclear-alkylated anilines and N : N-dimethylanilines are used to interpret their relative base strengths, while a study of substitutional changes upon the relative base strengths of the nitrogens in 4-aminoazobenzene assists in interpreting the spectra of these compounds in acid solution. The negative inductive effect of the dimethylamino-group and the relative rate-constants for the alkaline deacylation of 4-nitro- and 2 : 6-dimethyl-4-nitro-acetanilide were also discussed.

Finally, Dr. J. W. Smith (Bedford College, London) discussed dipole moment evidence regarding steric effects in aromatic molecules. Factors which interfere with the coplanarity of a group with the aromatic ring diminish the mesomeric effect and are reflected in the dipole moment. Thus, in *ortho*-substituted nitrobenzenes and N : N-dimethylanilines, μ(obs.) is less than μ(calc.). In anilines, however, an *o*-methyl inhibits mesomerism slightly, while the slightly larger bromine does not. Yet, dipole moment evidence shows that bromine has the greater steric effect upon nitro-, formyl, and acetyl groups. It is inferred, therefore, that the characteristics of the group are important in determining repulsions, and that bromine may have a smaller effective radius with respect to approach by hydrogen than by oxygen, and that the reverse applies to the methyl group.

G. W. Gray

OVERSEAS INFORMATION SERVICES

SPEAKING in a debate on the Overseas Information Services in the House of Lords on July 9, Lord Adrian stressed the importance of medical and scientific contacts in Commonwealth relations. Fellowships for advanced study and research to able young men and women, if properly used, were the best kind of information service we could give, and Lord Adrian thought we could well spend much more than the present £1 million on such contacts. He referred in particular to the Commonwealth Fund Fellowships, to the British Council's scholarships for postgraduate study and those of the Nuffield and Leverhulme Foundations. Other tributes to the work of the British Council were paid by Viscount Massereene and Ferrard, who, in opening the debate, also referred particularly to the importance of telling the world of our scientific and industrial achievements, Lord Birdwood, Lord Ogmore and by the Earl of Home and the Earl of Gosforth, who spoke for the Government. The Earl of Home assured the House that the Government wishes to strengthen and render more efficient all the information services, and stressed the importance of concentrating expenditure where it was likely to be most effective. In a notable tribute to the British Council he referred to the expansion in the number of Commonwealth students in Britain from between 2,000 and 3,000 in 1946 to 35,000 in 1957, when 11,000 were at universities. He thought, however, that the independent committee of advisers suggested by Lord Birdwood was unlikely to add much to the knowledge of the chief information officers of the Overseas Departments; but he agreed to discuss the proposal and also that of the Drogheda report for a permanent advisory committee with the Chancellor of the Duchy of Lancaster later.

Lord Croft raised the question of the export of British books, particularly scientific and technical text-books, which in countries like India, Pakistan, Burma and Ceylon had largely been displaced by United States text-books, partly in consequence of the aid and information programmes of the American Government. This situation seriously handicapped the sale of British products overseas, and because the distribution of British books and periodicals created a favourable climate for such sales he suggested the Government might, particularly in areas where competition is heaviest, give aid to all central libraries, university libraries and education centres abroad in the selection of British books on particular subjects. For this purpose an initial expenditure of £40,000 and an annual expenditure of £8,000 should service some 400 centres. He suggested also the organization of a limited number of exhibitions of books in areas not served by the British Council and the establishment of a Joint Standing Committee of the British Council and the Central Office of Information on one side, and a voluntary organization of the National Book League and the Publishers' Association on the other, to consider the whole problem. Lord Crook added that about 100,000 copies of books from the United States were being distributed at cut prices and that besides spending 5 million dollars on the translation, publication and distribution of books abroad, the United States, under a low-cost publication programme, had in 1957 launched 4·5 million copies of books in 185 editions and 21 languages. He also pointed out that although we invented the British Book Export Scheme, we did not use it, and because of the Treasury's attitude there were in consequence

no schemes for dealing with the position in Pakistan, in Israel and in Turkey. Even with the help of the Colombo Plan many Pakistan universities and libraries were unable to obtain the British books they need, and their science faculties had lacked all specialist periodicals over the past ten years; there was an unsatisfied annual demand there for £50,000 worth of British books and £15,000 worth of periodicals. The Earl of Gosforth, in concluding the debate, made no specific comment on this situation, but promised that all suggestions made in the debate would be carefully considered.

HOSPITAL SERVICES IN GREAT BRITAIN

THE debate on the hospital services in Britain, in the House of Lords on July 2, opened by Lord Nathan, was noteworthy both for the review of the first ten years operation of the National Health Service and for the stress which was laid upon medical research by Lord Nathan himself and other speakers. Lord Nathan said that while there had been no increase in the number of teaching hospitals, the number of beds had increased from 26,000 to nearly 28,000, and in the non-teaching hospitals from 475,000 to 481,000; the bed-occupancy had remained at just over 80 per cent in the teaching hospitals and increased from 79 to 83 per cent in the non-teaching hospitals. The medical and dental staff over the whole country had increased by about 30 per cent, and in the teaching hospitals the number of nurses had increased by 20 per cent, but only by 10 per cent in the non-teaching hospitals, where the number of out-patients was now about 18·5 million a year, compared with 9·5 million in the teaching hospitals in 1956 (an increase of 2 million on 1949). Lord Nathan referred to the increase in voluntary service in the hospitals, to the increased space demanded by new developments in surgery and treatment and, finally, to the extreme importance of research, including the value of sending staff abroad to study methods used elsewhere. We could not expect to retain in our hospitals or in Britain men of the right quality unless we provided them not merely with adequate remuneration but, even more important, with the opportunities for developing their powers and their careers within their profession to the utmost. As regards costs, Lord Nathan said that the Guillebrand Committee found that capital expenditure in 1952–53 was only one-third what it had been in 1938–39, and he added that running costs for 1958–59 were estimated at just under £400 million, an increase of 4 per cent on 1957–58.

Other points emphasized in the debate were the shortage of accommodation for elderly persons, the vital importance in the teaching hospitals of the personal influence of the teacher on the student. Lord Evans stressed the dependence of the standard of of our teaching hospitals upon this personal contact between teacher and student. He also suggested that the hospitals should be encouraged to seek additional sources of finance. Lord Moran referred to the importance of the redistribution and the increase in number of consultants, so that there were now available in almost every part of the country first-rate specialists in every branch of medicine, and he supported Sir George Pickering's suggestion that every drug in the Pharmacopœia should be investigated to see when it is necessary as the only way to reduce the drug bill of £74 million a year. Lord Addison said a brake might be placed upon research generally in teaching hospital groups, because of the difficulty in handing over to the Exchequer vote methods resulting from research activities after they had taken their place in normal clinical procedure, and suggested that some more frequent method of assessing the stages to which research had developed might be advantageous. Reference was also made to the great advance in the treatment of mental diseases, but Lord Pakenham thought that an expenditure of only 2 per cent of its funds by the Medical Research Council on research into mental health was inadequate.

In his reply for the Government, Lord Strathclyde pointed out that, since the Guillebrand report, capital expenditure had considerably increased and was now about £23 million compared with £12 million in 1952–53. He states that the Government fully realized the importance of research, and said that it fully accepted the value of travelling scholarships and that hospital boards had been given very considerable discretion to grant study leave. In 1948–57, £18 million out of a capital expenditure of £70 million had been spent on mental hospitals, and the percentage had risen from 23·9 in 1948–56 to 32·7 in 1956–57. The Government was also fully alive to the potentialities in the application of work study.

TRANSPLANTATION OF THE FOREBRAIN REGION IN BIRD EMBRYOS BEFORE THE ESTABLISHMENT OF A CIRCULATION

Homoplastic Transplants

IN a recent publication one of us described a technique by which the forebrain region of chicken embryos at the stage of development prior to the establishment of a circulation can be transplanted to hosts of a corresponding stage[1]. Successful auto- and inter-breed homo-transplants have been obtained. Some of the grafted embryos, including the graft, continued to develop in a fairly normal way up to the time of hatching. Further work with the forebrain grafts showed that some of the grafted embryos are capable, with very little assistance, of freeing themselves from the shell, and living thereafter for considerable periods. So far, five such animals have been obtained. Of these, one was an autografted Rhode Island Red, three were homografted Rhode Island Reds and one was a Rhode Island Red on to which the forebrain of a Barred Rock Black embryo was grafted. The autografted chick was killed 77 hr. after hatching. One homografted chick died 30 hr., another 36 hr. and the third 55 days after

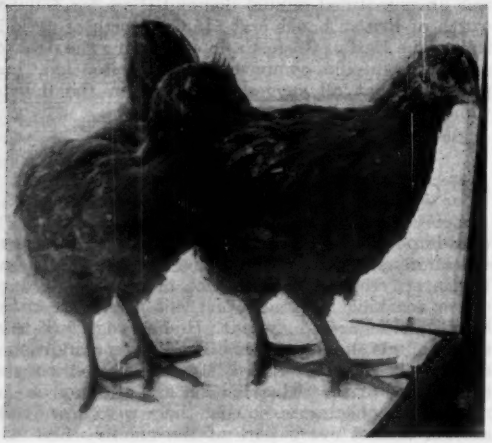

Fig. 1. Graft, Barred Rock Black; host, Rhode Island Red. Left, grafted bird; right, control. When photographed, this bird was 45 days old. The host is a female, the graft was probably taken from a male. Note deep toothed comb and absence of tail feathers

hatching. The Rhode Island Red to which the Barred Rock was homo-grafted is 60 days old and still alive; so far, its rate of growth has been nearly normal (Fig. 1).

One of the most frequently observed phenomena in such grafted chickens is a retardation in development, accompanied by lowered viability. In some embryonic chickens the incubation period was prolonged by 1–5 days; such birds failed to hatch. Anomalies in the appearance and in the distribution of pigment in inter-breed 'crosses' were also common.

In the chicks that hatched, retarded growth of the feathers and their anomalous distribution over certain regions of the body were also observed. In the two birds that survived for longer periods, especially in one of them, the rate of growth was less than that of normal controls. On the other hand, both of them had perfect control over their feeding reflexes; their movements were, or are, well co-ordinated, and the sight and hearing appeared to be perfectly normal. The functioning of the vocal organ was also normal. The autopsied embryos that have been examined so far had apparently normal pituitary glands. The hatched autografted chick was the only animal in which the pituitary gland was not found.

Crude operational technique may result in very imperfect healing between the two cut surfaces of the brain mass and, without unduly affecting the eyes and the mouth parts, give rise to profound disturbances in the anatomy of this organ. What type of healing is obtained with embryos that hatch, and how far the general state of the organism is affected by it, only further work will show.

Petar N. Martinovitch
Miroslava R. Pavlović
'Boris Kidrič' Institute for Nuclear Sciences,
Post. Fah 522,
Belgrade;
and
Osborn Zoological Laboratory, Yale University,
New Haven, Conn.
April 11.

[1] Martinovitch, P. N., *Proc. U.S. Nat. Acad. Sci.*, **43**, No. 4 (1957).

Heteroplastic Transplants

By the use of a technique originally applied to transplants of the forebrain region in chicken embryos[1], reciprocal transplants of the forebrain region between chicken and duck embryos were attempted. Figs. 1 and 2, of a chicken forebrain graft to a duck, and of a duck graft to a chicken, respectively, illustrate the possibilities of the growth and development of grafts between embryonic hosts belonging to two different species of birds. We have not, as yet, analysed closely the processes taking place in the course of development of these grafted embryos, but in their essentials they are similar to those observed in homografted ones. The establishment of vascular connexions between the host and the graft is somewhat delayed in comparison with that in homografted embryos and this may seriously affect further differentiation and growth both of the graft and the host. In spite of this, normal-looking eyes developed in both chicken-to-duck and duck-to-chicken grafts, and an almost normal upper beak in some chicken-to-duck transplants (Fig. 1). A fairly normal but retarded upper bill was formed in a duck-to-chicken transplant (Fig. 2).

Fig. 1. Graft, Rhode Island Red; host, Khaki Campbell. Embryo removed from the shell on the 22nd day of incubation. The mandible has developed from the host tissues, and the upper beak from the graft

Fig. 2. Graft, Khaki Campbell; host, Rhode Island Red. Embryo removed from the shell after 23 days of incubation. The right eye and the upper bill are well developed; the left maxilla is defective

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BRITISH ASSOCIATION MEETING IN GLASGOW

SCIENCE AND BUSINESS: A BALANCED PARTNERSHIP*

By Sir ALEXANDER FLECK, K.B.E., F.R.S.
President of the British Association

THE British Association has returned to Glasgow after the passage of some thirty years. The president on that last occasion was Sir William Bragg, and it is good to know that his son maintains a fine scientific tradition as director of the Royal Institution and of the Davy Faraday Laboratory. We are glad to have this opportunity in the course of our scientific deliberations to see something of the progress that has taken place in Glasgow and its region since then. In 1928 the Scottish Lowlands were reasonably prosperous: they had not yet entered the lean and hungry years of industrial depression when men's labours ground to a standstill and unemployment paralysed much initiative. As is well known, the depression lasted until early 1939, to be followed by the trials of war, death and destruction from the air, and all the while the deluding sense of prosperity that war brings. Since the end of the War, Glasgow has seen great industrial activity, though there are again threatening clouds in the sky.

But Glasgow's story goes back far beyond the fluctuating fortunes of the past thirty years. The little Cathedral town which emerged from the sixth century settlement beside the Molendinar has become one of the greatest cities of the Commonwealth. The shallow, unpolluted Clyde has become the deep-dredged channel which has carried the world's largest ships, a source of trade and prosperity to Scotland.

We of the British Association pay tribute to the creative scientific thought of the citizens of Glasgow which has enriched the world: first, Adam Smith, original economic thinker, who stood between the two storms that broke over Scotland—the Reformation and the Industrial Revolution; then the chemist, Joseph Black, whose work on the theory of heat helped to inspire James Watt, himself prime mover of the Industrial Revolution. Lister, a past president of the Association, came to revolutionize surgical methods; Kelvin, another president, established principles of thermodynamics and electricity, and so 'put a girdle round about the earth'. In our own time, Soddy's work on atoms helped to name the new atomic age, presently so much in our minds.

These are some of the men who towered above their contemporaries and their century, men whose names make the British Association proud to renew its contact with the City of Glasgow and recall the debt that the world owes to it.

We hope that the citizens of Glasgow will always, in the same inspiring tradition, promote the advancement of science, technology and philosophical thought.

I am very sensible of the honour that the Council of the British Association has done me by electing me president for this Glasgow meeting and so enabling me to come back with the Association to the place in which I first saw the light of day just on the south bank of the Clyde. The surroundings there were all of trade and business, so I trust I can with appropriateness express some general thoughts on business and science and the need for a proper balance between them. This subject is very different from those chosen by most of the presidents who have addressed this Association in the 127 years of its existence: they have spoken from the wealth of their expert knowledge of some science to which they have added great lustre. There is no science with which I, on the other hand, can claim the intimate acquaintance of a practising scientist. It is many years since I worked at a laboratory bench and experienced the excitement of anticipation all research workers feel as a well-planned experiment approaches its conclusion. That phase passed into one in which I supervised and directed others to do such work, and later that also was left behind under the pressures of full-time administration. The result of all this is that I am no specialist in any branch of science. Rather, I approach my task here as a sort of common man of science, who, lacking the detailed knowledge of the specialist, has at least an understanding of the framework within which scientific thought evolves.

All the same, it may be felt that in my dual capacity as president of the Association and as an administrator, I run the risk of finding myself a business man among scientists and a scientist, even if only a lapsed scientist, among businessmen. Perhaps I may remind you of a remark ascribed to Talleyrand: "War is much too serious a thing to be left to military men". I have the impression that the same sentiment may apply both to the conduct of business and to the advancement of science. The risk of being neither pre-eminently scientist nor pre-eminently businessman may be counterbalanced by advantages that come from a non-specialist approach to science and business. I hope to show why such an approach may be particularly appropriate to the needs of the moment.

Science

In a population which depends so much on science, it is sad to think how few people clearly understand what it is all about. It is an approach to an understanding of the universe along a broad highway of organized knowledge firmly founded on observation

* Presidential address delivered in Glasgow on August 27 and appearing in the September issue of *The Advancement of Science*.

and experiment embedded in a matrix of theory. It is a highway which is constantly being widened and extended and repaired. We are building it because we think that, by and large, it is a good road for mankind to travel, and that it is leading him away from ignorance and wretchedness towards a fuller life and a better world. Some find that the act of extending the highway gives them all they seek from their life-work: these are the pure scientists, and much of our progress derives from them. Others find greater satisfaction in utilizing what has already been built, pausing perhaps to strengthen it here, widen it there: these are the technologists, or applied scientists. A few people combine both functions, driving the road forward into undiscovered territory, then paving it ready for all to use. Whatever our own work may be, we have a joint responsibility to see that the highway is properly and extensively used by all mankind. It is therefore fitting that the British Association is now devoting itself to the additional task of securing the greater use of this highway by all types of people in these islands, more especially as we enter what is often called the Second Industrial Revolution.

In the First Industrial Revolution man learnt to convert chemical energy, derived from the reaction between carbon and oxygen, not merely into heat but also into mechanical energy, steam being the key to the process. In the Second Industrial Revolution we are turning from the external properties of carbon atoms to the internal properties of the lightest and heaviest atoms in Nature as a source of energy to expend as prodigally as we like, thus husbanding carbon atoms as a source of materials.

Another feature of the Second Industrial Revolution is the growing interdependence of the sciences as they advance on a broad front. To review the achievements of the past year or two alone, the launching of the Russian and American Earth satellites depended on prior developments in several different sciences and technologies. Chemical rocket fuels, refractory combustion chambers, and radio transmitters which dispatched back to the Earth information of great relevance to the theme of the International Geophysical Year, all played their part. Miniature transmitters themselves followed the invention in the Bell Telephone Laboratories ten years ago of the transistor, which in turn owes its successful development, at least in part, to the perfection of methods for separating traces of boron and other elements from silicon to a degree of purity exceeding one part in a thousand million.

All of us here recognize the creative possibilities of thermonuclear fusion energy opened up by the Harwell and Aldermaston experiments on high-temperature electric discharges. Although most of the neutrons so far produced have not originated from thermonuclear fusion, there can be no doubt that ZETA and SCEPTRE are symbols of man's reach into a future of boundless energy; his grasp of such a prize could well rank as his greatest material achievement in the history of the world. In such experiments as these, as indeed with the discovery of nobelium, a pre-requisite of success is a flourishing electrical industry which can provide many of the tools of nuclear physicists.

Scientific effort on this scale costs money; indeed, the total annual research expenditure in Great Britain alone is estimated to be £300 million. Such effort also costs scientists. Public expenditure on education (including the universities) in Britain is now some £740 million a year; if our universities are to grow large enough to accommodate everyone who could benefit by such an education, instead of merely the 3½ per cent of the population who enjoy it now, then we shall need to contemplate spending something nearer £1,200 million a year. These are large sums, and if, as a nation, we are to stay solvent they can only come from one source, the wealth which we produce.

Business

In this context it is easy to see the importance and responsibility of business, which produces and distributes most of our national wealth. Our capacity to extend our science and education largely depends on our ability to run business successfully. Lewis Mumford in his "Technics and Civilization", written in the 1930's, though he appears to exaggerate their numerical importance, suggests that it may have been no accident that there were merchants of the City of London who played a part in the early days of the Royal Society. He directs attention to the affinity of science and business when he writes: "The power that was science and the power that was money were, in final analysis, the same kind of power: the power of abstraction, measurement, quantification".

On an occasion such as this it is difficult to avoid being at once too general and too particular. I have chosen to speak of business because business is a more comprehensive term than industry. At the same time I intend to limit my scope primarily to the larger units, although naturally I recognize the importance of the smaller organizations—indeed, in manufacturing industry alone, three-quarters of all establishments employ fewer than a hundred people.

Defining the limits of my subject in this somewhat arbitrary way will, for the moment, do service for a formal definition of the term 'business'. After all, it is a vague word, perhaps for euphemistic reasons in the past even deliberately vague. Nevertheless, I venture to put forward three characteristics which I think a business should have if it is to survive and function effectively over a period of years.

(*a*) First, it must contribute to the well-being of the community and its social evolution. I believe it can best do that in three specific ways: by producing goods or services for the community at fair prices; by giving fair treatment in the way of remuneration and working conditions to all who give their services to the business, whether as payroll employees, administrators or scientific staff; and by giving a fair return to those who risk their money in the business, so that, apart from this consideration, they will be encouraged to provide again for further ventures. When business takes on itself the deployment of financial, material and human resources, it also takes on, I believe, the responsibility for seeing that they are properly and effectively used. In other words, it has an obligation to the community: and only in so far as it fulfils that obligation does it contribute to the well-being of the community and justify its own existence.

(*b*) Second, business must have the capacity to change its methods and if necessary even its objectives. It must be constantly alert to see that its products or services meet or anticipate the needs of the public, and to withstand the nipping and eager air of competition whether it comes from advancing techniques or from new entrants into the field.

(c) Finally, if it is to be self-perpetuating through growth or modernization, a business must dispose of its products or services for more than their cost—or in plain language, it must make a profit. That is true of business whether run by private enterprise or by the State; nor does the political system of the State make any difference to the validity of this notion. Only from the excess of income over expenditure can we finance the expansion of business and science.

This brings me again to the reason why I have chosen to talk about business rather than industry. It is an old saying that money makes money; by the same token the production of wealth requires the investment of wealth, and such investment can come from a variety of sources. Traditionally, part comes from retained profits, that is from what economists in the past called the abstinence of the individual manufacturer, or in to-day's terms, from the undistributed earnings which companies plough back into the business. Part comes from the banks, though their function in Britain has usually been to provide working capital in the form of loans and overdrafts, rather than to provide fixed capital like the industrial banks of Germany, which played such a prominent part in the organization and growth of industry in that country. Indeed, we can share Disraeli's suprise that the London money market played such a small part in the financing of the railways. In "Endymion", published in 1880, he wrote: "What is remarkable in this vast movement is that the great leaders of the financial world took no part in it . . . even Lombard Street which never was more wanted, was inactive, and it was only by the irresistible pressure of circumstances that a banking firm, which had an extensive country connexion, was ultimately forced to take the leading part that was required". To-day by far the largest volume of capital comes from the investing public as private individuals or financial institutions, working with a vigorous and well-informed Stock Exchange.

There is, of course, no exact relationship between the amount of income which a country ploughs back into capital formation and the rate of economic growth which it achieves. Nevertheless, I think that certain generalizations can be offered. For example, we can compare the experience of the United States with that of Great Britain. Between 1870 and the First World War, the United States devoted more than one-fifth of its national product to home investment, and the United Kingdom only about one-tenth. During that period its national product grew by more than 4 per cent per annum compared with less than 2½ per cent in Britain. More recent history, in spite of occasional and, one hopes, temporary setbacks here, suggests the same lesson: over the past forty years, the United States has invested about half as much again in relation to its resources as we have, and its national product has risen at an average rate of about 3 per cent per annum, against only about 2 per cent in the United Kingdom.

I do not wish to strike a note of disappointment so much as to recall the classic virtues of abstinence, saving and investment. In fact, during the past ten years the amount which the United Kingdom has invested in its productive resources has shown an encouraging growth, with the apparent result that output in manufacturing industry, as a whole, has increased by some 3½ per cent per annum since 1948, compared with about 2½ per cent between the two World Wars. If science has laid the foundation for much of this expansion, business has provided the will and the means to complete the structure, and both must continue to do so.

There is another reason why it is important that this partnership should continue to flourish. We have in the British Isles more than 50 million people who enjoy a material standard of living surpassed in few other countries in the world. Our mineral resources are limited and indeed declining. It is by means of the goods produced by manufacturing industry and the services provided by finance and commerce, in short by business as a whole, that our 50 millions are enabled to live, and on the whole to live tolerably well, in an area too small to feed them, at least by present methods.

All this is commonplace, but like much that is commonplace, it is easily taken for granted until we remember that more than 90 per cent of the world's population live in countries less prosperous than our own, most of them in conditions that we should not dream of tolerating. The world does not owe us a living; we can only enjoy the standards which our business enterprise and scientific knowledge enable us to earn through our exports. Like all countries depending on their export trade for a livelihood, we in Britain have a vested interest in economically and politically stable conditions throughout the world—and I mean stable, not static, conditions. Stability will not be achieved, for example, if plans for industrialization of the less-developed territories are obstructed from a misconceived notion that we may thereby be able to retain our own markets for that much longer. To those who heard Prof. P. M. S. Blackett's plea last year for technological aid to the under-developed countries, this may sound an unnecessarily narrow approach. But I have deliberately couched my argument in terms of expediency rather than moral compulsion, because it emphasizes one respect in which the combination of science and business seems to me to be vital, and it is this: we must concentrate for our own survival on the development of new products and new processes.

Our old staple exports of textiles, iron and steel, and coal have long since given way to newer lines—vehicles, aircraft, machinery, chemicals and electrical goods. Even here the pattern keeps changing. Motor vehicles, fine and heavy chemicals and so on, are increasingly being manufactured in countries which previously produced only food or primary raw materials. In India, I am told, a company manufacturing diesel engines and electric motors is exporting 30 per cent of its output. Chemicals from Red China and mass-produced toys and torches from Hong Kong are met in many of the world's markets. We are therefore obliged to rely either on selling things which no one else has yet learnt to make, or make as cheaply, or on marketing our skill and 'know-how'.

It is not difficult to find examples of what happens to our business when 'rule of thumbism' is preferred to operations guided and controlled by science and technology. I think there would be general agreement that at various times some of our traditional industries in which we were pioneers have suffered from the lack of proper scientific direction.

In my own industry, organic chemicals once experienced the same neglect. The lead that Perkin had given to our synthetic dyestuffs industry with mauveine was frittered away through lack of scientific effort. In the presidential address to the Chemical Society in 1915 his son, William Henry Perkin Junior, referred to this neglect in these words:

"My experience of the manufacturer in this country is that he is usually merely a commercial person who does not like the expert, and especially the idea of giving the expert a prominent position in the control of his works. Possibly the reason in many cases is ignorance of the value of science, but more probably it is due to the fact that being ignorant of science himself, he feels that if the expert is given too much prominence he must either study himself in order to understand the expert or leave the essential control of the business in his hands. Both these courses are distasteful to the ordinary commercial member of a board of directors; the expert is therefore relegated to the background, and the business comes to grief".

The lesson has not yet been fully learned, for even to-day we meet this attitude. I have a quotation here from a managing director who went on record last May. The scope of his company may be small and may be provincial, but that the sentiment still exists in minds capable of directorial control is significant. He writes: "The place of the expert is not in the saddle but as the assistant and the adviser. The scientist must be on tap, not on top". Such a relationship is very different from the partnership of science and business that I have in mind.

I have considered briefly some reasons why I regard the partnership of science and business as fundamental. To recapitulate, first it is because, if science is to carry forward our social evolution, it needs the financial and productive effort of business; and second, because the prosperity of Great Britain depends on the technologically sophisticated products of our export trade.

A Balanced Partnership: How to Achieve it

(*a*) *The scientist in the business structure.* I should now like to examine how this partnership can be achieved in practice, by considering the place of the scientist in the business structure. In a technological business we can distinguish some six or seven separate functions, depending to some extent on their definition: finance, commerce, personnel, operation or production, design and construction, research and development. I propose not to elaborate on these functions fully, but to touch on one or two of their features.

First, research: research has been called the life-blood of industry, but I prefer to liken it to the pituitary gland which, I am told, after doing little that is obvious for several years except consume nourishment, at length stimulates other parts of the organism to develop and makes it capable of production.

Research applied to business can take different forms, and one example within my experience may be given. It began with a research manager's conviction that a new inhalant anæsthetic was needed which should have the following properties: it should be a volatile liquid, with high anæsthetic potency, and be free from toxic, explosive and fire hazards. These criteria, he argued, pointed the way to aliphatic halogen compounds containing little hydrogen and especially to compounds with two or three fluorine atoms on the same carbon atom—groupings which are known by organic chemists to be not only unreactive in themselves, but also to strengthen neighbouring carbon-halogen bonds. The resulting inertness is one of the factors in avoiding toxicity; and the use of fluorine rather than other halogens keeps the volatility high. He also proposed a new method of expressing dosages which made it possible to relate, by using a principle of chemical thermodynamics, the amount of anæsthetic in the inspired air to that in the body fluids. This helped in the selection, for biological testing, of compounds likely to have the desired potency, among which the one finally chosen was 2-bromo-2-chloro-1 : 1 : 1-trifluoroethane, a new compound synthesized especially for the purpose.

The major research effort, which for the first two years fell to the organic and physical chemists, had at this stage passed to the pharmacologists, whose screening tests took some three years. They showed that the new compound had not only the properties sought, including a high margin of safety from overdose, but also some unexpected advantages. Clinical trials with successful results began six years after the research started, and meanwhile manufacturing methods were developed by chemists and engineers, leading to general release to the medical profession two years later.

There are several features about this much abbreviated story, some of which are relevant to my present theme. It illustrates, first of all, the systematic application of pure scientific principles to a desired and well-defined end which, though primarily commercial, is not without social implications. Second, the research threw light on the physico-chemical basis of anæsthesia, which time, if no other reason, forbids me to enlarge upon. Third, success was crucially dependent on the existence of a team of specialists in several scientific disciplines and also in the somewhat recondite technology of fluorine; notwithstanding these favourable circumstances and adequate financial backing, the research and development took seven years. Fourth, the distinction between the research and the development function of business is brought out: the original synthetic and early testing work was research, while the development consisted of devising suitable methods of manufacturing and launching the chosen compound, and of studying its clinical effect.

I now turn to the functions of design and construction, which are essentially the field of the technologist or engineer. His grasp of scientific principles, combined with the creative skill of a Telford or a Fowler, fits him above all to build a bridge between science and business. It has been said: "The establishment of the class of engineers . . . is the more important because this class will, without doubt, constitute the direct and necessary instrument of coalition between men of science and industrialists, by which alone the new social order can commence". These words of Auguste Comte remain as fresh and as true to-day as when they were written more than a hundred and thirty years ago.

The production or operation function includes the application of technical methods often according to a routine, though it also demands much planning and organization. Although such work is sometimes considered humdrum and repetitive compared with research and development, it is often essential for it to be done by highly qualified technical men. It is just as great a mistake to believe that unqualified men who come up what used to be called 'the hard way' are generally adequate, let alone best, for production work, as to hold that good technical people are wasted in such jobs as plant management. On the contrary, they must be encouraged to regard it as an interesting and necessary part of their training for higher management.

If there are to be no weaknesses in any one part of the organization, technical staff may have to be moved from one department to another, and this places a vital responsibility on those exercising the personnel function in selection, training and promotion; at the same time it is their duty to ensure that employees can find satisfaction in their work. This function also can be conveniently performed by a scientist, whose knowledge of what the technical departments require helps him to place staff to the best advantage, both of the business and themselves.

On the commercial side also, scientists may be needed in sales, sales service or purchasing, to achieve the best results for a business making technically complex products. I cannot agree that employment of technical men in commercial departments is necessarily wasteful: it gives flexibility within the business, and can often ensure smoother co-operation when a works manager or research chemist feels that his own—the technical—point of view is understood by a man in one of the commercial departments; moreover, as training for higher administrative posts, commercial experience is invaluable to the scientist.

When he reaches such a post, the scientist, recognizing the value of science in business administration, will be well placed to exploit it. I am not thinking here only of new equipment in the office, such as electronic computers or apparatus for sensing letters and figures; science has more to offer than mere tools. It offers the whole philosophy of the scientific approach to the problems of management. I need only mention some of the steps involved: definition of the problem, observation and collation of the relevant facts, formulation of a hypothesis or principle. its testing and its general application.

This approach has been of untold value in the examination of human activity and its measurement, which is usually described as work-study. It has also been very successfully employed in the problems of supply and distribution, in adjustments of stock-levels and in planning of delivery programmes. The full application of such methods usually involves some specialist techniques, especially of a mathematical kind; but even the first qualitative steps of the scientific approach can often lead directly to improvements in business efficiency. All the same, it is worth noting that an otherwise successful application of such techniques can founder on the inability to handle human relationships with proper understanding.

Finance has played a conspicuous part in my address and, in my experience, no technological business ever attempts to progress without continually seeking financial advice. However, I have failed to see in Great Britain an equal acknowledgment that financial institutions need to take the benefit of continuing technological advice, though I am glad that some progress is being made in this direction overseas. For example, I know of a bank specially interested in natural resources which employs full-time geologists. Again, the World Bank Organization in Washington employs technical men not only at headquarters but also to carry out specific missions in various countries. Finance and technology will, I hope, become more and more interdependent as our businesses adapt themselves to current needs.

There is scope then for the scientist to infiltrate throughout almost the whole business structure. That being so, it is pertinent to ask, if scientists are to play an important part in business administration, is the balance between science and business likely to be upset? The answer to this question is, I think, threefold.

First, as British industry is at present constituted, the balance is heavily tilted the other way. That is to say, there are still many enterprises which are not employing qualified technical men even in tasks where one would expect to find them, and conversely there are no industries that appear to be harmfully dominated by scientists. This is due partly to the shortage of scientists and technologists with which we are all familiar, but partly also to historical circumstances. In the nineteenth century, due to Britain's wealth of practical engineering experience, theoretical knowledge was under-valued. At the same time, an educational bias towards the classics, based on an aristocratic tradition, sometimes led the second and third generation of a manufacturer's family to forsake the business altogether for politics or the Bar, or if not, at least to be quite unfamiliar with the value of science. Again, as we have seen, in some concerns scientists are relegated to the position of advisers to management and are allowed little part in the active control of the business.

Second, in businesses where scientists rightly play a prominent part in administration, non-technical men who nevertheless have a good understanding of scientific principles are with advantage sometimes put into semi-technical jobs, and this helps to maintain a balanced partnership.

Third, and most important, the balance that we seek must come in great measure from within the individual himself, a balance provided by the education which the scientist and the non-scientist ought to receive. This, besides being central to my theme, is very much the personal concern of many of us here.

(*b*) *Balance in education.* There are three senses in which we might consider balance in education. The first arises from two different conceptions of the purpose of education. On one hand there is the formation of character and the development of intellect and personality. At the other extreme is the concept which I suppose finds its most powerful expression in the educational philosophy of Soviet Russia, that the purpose of education is to provide useful members of society in which the desires of the individual must be subordinated to the needs of society.

I do not believe that these two concepts are wholly conflicting or that the second runs completely counter to the British tradition of individual liberty. A balanced educational system should have room for both. The striking successes achieved by the Russians in science and technology are directly attributable to a system of education deliberately designed to produce large numbers of technically trained men and women with the ability to increase the economic power of the country through industrialization. To this end they established a strong teaching profession to which recruitment is no problem, because it enjoys the highest pay and status of all the professions. Though undoubtedly State direction still has a place in the Russian educational system, its purpose is being achieved to an increasing extent by incentives.

We are proud that the universities of the United Kingdom, despite their growing financial dependence on the State, still retain their academic independence intact. Nevertheless, they have quite properly reacted to the stimulus of the country's needs which have led the older universities, for so long the home of the humanities, themselves to enlarge their science

faculties. The new St. Catherine's College at Oxford and Churchill College at Cambridge will give particular prominence to the study of science. The introduction of transfer scholarships to enable promising arts men to turn to science has been readily accepted. More sixth-formers are reading science in the public and grammar schools. Some long-term financial incentives may operate here, but more important has been an intensive propaganda effort which, I hope, will be sustained by the British Association's programme for organizing lectures up and down the country on the lines of those so successfully pioneered by the Royal Institution in London.

So, in framing our formal education, we cannot entirely ignore the requirements of the society on the prosperity of which depend the very conditions in which our educational system can progress; but our society will not be tolerable to live in if its members are not permitted to develop their personalities and talents.

This brings me to the second sense in which I refer to balance in education. I am thinking here of the need for those who study the humanities to have some understanding of the workings of science, and for our scientists to widen their horizons by relating their science to its human context both historically and in terms of the present day. I have in the past on several occasions declared my belief that the gulf which at present separates our scientists and non-scientists is much more easily bridged than is often imagined. For example, the qualities of mind which are fostered by studying chemistry and history are very much alike. Both chemists and historians must cultivate an inquisitive and acquisitive mind. Both need to exercise judgment, leavened with a good measure of scepticism in the exemplary tradition of Robert Boyle. Both must be imaginative, the chemist in advancing hypotheses to predict the future, the historian in doing so to explain the past.

The merits of a balanced curriculum are recognized in Soviet Russia, where children between eleven and seventeen devote something like 46 per cent of their working hours to science subjects, with the emphasis predominantly on mathematics, and another 46 per cent to what we would call arts subjects, with the emphasis here on Russian language and literature. Clearly a correct balance can never be achieved with premature specialization, which the current demands for entry into many universities impose on our most talented students.

There is a third and final sense in which I refer to balance in education. I have said that we demand, from our scientists and non-scientists alike, intellectual qualities, such as curiosity, judgment and imagination. Equally we want our young people, whatever their branch of study, to possess high qualities of character. I need not enlarge on this theme except to say that the society which a balanced partnership of science and business can help to build will as always call for courage, integrity and tenacity. These are some of the ideals that we might have in our minds as we each address ourselves to the problems of education for an age of science.

My theme has been broad and general. It does not call for revolutionary action; it calls rather for sustained progress, and, of the two, that is sometimes the harder to inspire.

In education, Glasgow has an enviable reputation. I have already referred to some of the famous names connected with the University. Alongside its fine academic tradition, we can rejoice in more than 150 years growth of higher technical education. The Royal College of Science and Technology, as its name has been since 1956, can trace its origins back both to Birkbeck's Mechanics' Institution and also to Anderson's College, founded in 1796, where Birkbeck himself taught.

Where such institutions exist to teach and practise science, and where there is still the business acumen and mercantile tradition of the Glasgow 'Tobacco Lords', I hope my plea for extending the partnership between business and science will fall on fruitful ground. In Glasgow, so long ago as 1799, Tennant exploited the discovery of chlorine to found a large chemical business. Again, in this City was discovered the cyanide process for separating gold from its ores, a process which has enabled gold to this day to be mined on a scale massive enough for it to be still a measure of world finance and commerce. Symington's *Charlotte Dundas* and Bell's *Comet* were forerunners in the technology of power-driven ships such as have made the Clyde shipbuilder's skill famous throughout the world. Kelvin's fundamental work on electricity and his maritime interests led him to found a business based soundly on practical physics.

I have tried to show why science and business must be partners: the advancement of science can only be achieved with the resources which business can provide and, if business is to provide them, then it must bring science to its aid. I have also suggested that a truly balanced partnership will manifest itself in the growing use of science and its methods in business; and that it can only come from a balanced education for scientists and businessmen alike.

I believe this balance to be important for our well-being, and as we inaugurate this 120th meeting of the British Association, we can take with sincerity and all humility for our own work, the objective for his college expressed in Anderson's will:

"For the good of Mankind and the Improvement of Science".

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

SOME ASPECTS OF THERMONUCLEAR RESEARCH

DR. T. E. ALLIBONE discusses in his presidential address to Section A (Mathematics and Physics) some aspects of thermonuclear research.

If the fusion of deuterium ions is to yield a useful amount of energy, the temperature of the gas must be maintained in excess of 100 million degrees, and it therefore follows that the hot gas must not be in contact with the walls of the vessel containing it. A large current passed through the gas will heat it ohmically and the magnetic force associated with the current will constrict the discharge and draw it away from the walls, thereby compressing it and thus augmenting its temperature. Many investigators have pursued this line of research; British investigators have mainly used toroidal discharge tubes in which a pinched ring discharge is created by electromagnetic induction, whereas American and Russian investigators have used straight discharge tubes, thereby choosing to ignore, for the time being, end losses at the electrodes.

Very large electric currents lasting for short times were readily produced in the straight tubes and bursts of neutrons were detected several years ago. The fact that the bursts of neutrons lasted for only a few tenths of a microsecond and occurred only two or three times throughout a 10-microsecond current pulse was surprising; moreover, the rate of release of neutrons was far higher than could be accounted for. It did not rise appreciably as the discharge currents were increased, and it diminished rapidly if impurities were present. Further study revealed the fact that the discharge developed instabilities in a few microseconds, and at localized constrictions of the discharge, ions were given energies far higher than their mean energy. It was the collisions of these locally accelerated ions which produced the fusion reaction yielding the observed neutrons.

The toroidal discharges studied in the Atomic Energy Research Establishment at Harwell and at the Research Laboratory of Associated Electrical Industries, Ltd., at Aldermaston were maintained for times of the order of a millisecond, during which other forms of instability developed. To a certain degree it was found that these instabilities could be reduced by the application of a steady magnetic field parallel to the discharge path. As the discharge is constricted in the presence of this axial field, currents circulate around the cross-section of the discharge, thus enhancing the field within the discharge and reducing the field outside it. It was found that with optimum values of applied axial magnetic fields the toroidal discharges yielded neutrons over a large fraction of the total duration of the current pulse, both in the apparatus ZETA at Harwell and in SCEPTRE at Aldermaston. Moreover, measurement of the Doppler broadening of some of the spectral lines of impurity elements in the gas indicated ion temperatures corresponding to several million degrees, at which true thermonuclear fusion should yield neutrons comparable in number with the observed neutron flux.

In recent months it has been proved that neutrons and protons released in the fusion reaction in the same direction as the ions in the discharge have energies a little higher than those emitted in the opposite direction; the difference is due to the forward velocity of the deuterium ions at the moment of fusion. This velocity has been found to be appreciably in excess of the mean velocity of deuterium at the temperature estimated spectroscopically. It may be that the spectroscopic measurement is in error, for the discharge, though reasonably stable, can be seen to be moving about rapidly within a confined volume on the axis of the torus, and some of the Doppler broadening may be due to lateral velocity of the beam. To resolve some of the anomalies and uncertainties, ZETA and SCEPTRE are being modified to operate at higher temperatures.

Some of the other ways of attaining high gas temperatures appear to be very promising. Following disclosure of the Russian linear pinch discharge, the Atomic Weapons Research Establishment, Aldermaston, has developed an even faster linear pinch which has produced neutrons; preliminary indications are that these do not arise from instabilities of the discharge. The most recent American and Russian work will be discussed in Geneva on September 4 and may not be commented upon at this moment. Several novel methods of containment of a plasma have been described in recent American literature, but the Russians have disclosed nothing since 1956.

THE CHEMISTRY OF THE TRANSURANIC ELEMENTS

PROF. H. J. EMELÉUS, in his presidential address to Section B (Chemistry), states that it was a natural result of Fermi's observation of the n,γ reaction, whereby an element such as gold could absorb a neutron and by subsequent β-decay be converted into a mercury isotope

$$\left({}^{197}_{79}\mathrm{Au} \xrightarrow{n,\,\gamma} {}^{198}_{79}\mathrm{Au} \xrightarrow{\beta} {}^{198}_{80}\mathrm{Hg}\right)$$

that similar experiments should be done with uranium in the hope of making isotopes of a then unknown element 93. Irradiation of natural uranium actually gave both fission of uranium-235 and neutron-capture by uranium-238. From this confused start, however, clear-cut methods for producing the transuranic elements have now emerged. These are, in brief: (1) bombardment with artificially accelerated particles; (2) neutron bombardment; (3) multiple neutron capture; (4) bombardment with heavy

ions. By using these methods, physicists and chemists jointly have now produced ten new elements ranging from neptunium ($Z = 93$) to nobelium ($Z = 102$).

In considering the chemistry of these elements, much attention has been given to the place which they occupy in the Periodic Table, and it now seems certain that they constitute a new group analogous in electronic structure to the rare earth elements. This implies that the 5*f*-electron shell is progressively filled. It would have its maximum complement of fourteen electrons in the hitherto undiscovered element of atomic number 103. This electron assignment is based, first, on the analysis of the emission spectra of some of the elements in question. Secondly, the magnetic properties are analogous to those of the rare earth elements. Thirdly, crystal structure determination of many solid compounds of the new elements have enabled values of ionic radii to be assigned. These show a decrease as the series is ascended, which parallels closely the well-known lanthanide contraction in the rare earth series. Absorption spectra of the transuranic elements also show characteristic sharp absorption bands, associated with transitions within the shielded 5*f*-level.

Chemically, the new elements differ from the rare earths in that, instead of having predominantly a valency of three, higher values are found. This is associated with the great ease with which the electrons are lost.

The maximum valency of 6 is most stable in uranium, but it is also observed in neptunium, plutonium and americium. Curium and berkelium, the next two elements, have valencies of 4, but, so far as is known, the higher members of the series are restricted to a valency of 3. Of the chemical techniques which have been applied in this work two may be mentioned specially. The first is solvent extraction, which is widely used in laboratory work and also plays an important part in the technical separation of plutonium from uranium and fission products. The second technique is ion exchange. The chemistry of the new elements is, for the most part, studied with minute amounts of material far below the limits that could be weighed with a chemical balance. Here the classical techniques of tracer chemistry have been revived and developed. It is the use of tracer technique which has shown that the higher members of the series are restricted to a valency of 3.

The discovery of so many new elements in the past twenty years naturally leads to speculation as to where this process will end. Present indications are that there are very few others which will be stable enough to survive. Stability is limited both by radioactive decay and by spontaneous fission. Nevertheless, a careful search is at present being conducted to extend the field. This work offers an unusual challenge not only because there is such a large unexplored region but also because it calls for very precise and painstaking research.

BENEATH THE EARTH'S CRUST

PLANS recently made to drill a borehole some ten kilometres deep, which may provide information about the Earth's mantle, prompted Prof. L. R. Wager, in his presidential address to Section C (Geology), to review existing ideas on the material of the mantle and to consider the implications if it proves to be similar to the alpine type of peridotites.

Current geophysical evidence suggests a model of the Earth in which the relatively light crust, of variable composition and thickness, rests on the far more uniform and dense mantle at depths of about 10 km. under the oceans and 20–50 km. beneath the continents. The mantle is characterized by a velocity of propagation of compressional waves of about 8 km./sec. and a density of 3·3. It is thought that the sub-crustal material is in a crystalline rather than liquid state down to 2,900 km., beyond which is the apparently very dense liquid core, presumed to have a nickel–iron composition. The facts of isostasy show, however, that, despite the solid condition of the mantle, it must be capable of flowing under sustained stress.

Of the known igneous rocks those with the closest approach to the observed physical properties of the mantle are the peridotites and related olivine-rich types. Some peridotites (for example, those of Sgurr Dubh in Skye) are the result of accumulations of olivine crystals from large masses of associated gabbros and may be described as autochthonous cumulites. Others, however (the alpine type), are common in fold mountains or island arcs, and are not associated with gabbros; these are considered to be possible samples of the upper mantle. It can be shown that basaltic magma could be produced by partial melting of peridotite; a peridotite mantle might therefore explain the world-wide distribution of basaltic rocks.

It is possible to postulate a mechanism for the formation of the Earth's silicate shell based on analogy with layered intrusions. The Earth is considered to have passed through a liquid stage. Convection currents due to cooling from the outer surface would establish a thermal gradient less than the gradient of elevation of melting point due to pressure. Consequently, crystallization of high-temperature minerals might be expected to occur from the bottom upwards. As the column of accumulating minerals increased in thickness, its weight would eventually lead to the expulsion of liquid in the pores, consisting of the components of lower melting point, from the lower parts.

The nature of the crystal phases earliest to separate is uncertain. But by the time the accumulation had reached about 200 km. from the surface the liquid was probably close to forsteritic olivine in composition, and olivine, enstatite and chrome spinel would be the primary minerals precipitated. Later, plagioclase and augite would be expected to form, and finally, when crystal accumulation had reached to within about 10 km. of the surface, a residual liquid of granodioritic composition would be expected, which further cooling would form into the crust. During this long process, convective action must have been modified partly by the heating effects of the radioactive constituents of the fluid expelled from the mush and partly by the changing mechanical properties of the solidifying mantle. In particular, convection currents would be very restricted in the later stages, when the crust had solidified. Perhaps a major convective overturn in the mantle at an intermediate stage, before final solidification of the crust, was responsible for pushing the sialic scum into the restricted areas now occupied by the continents.

SOME BIOLOGICAL EFFECTS OF LOW TEMPERATURES

THE presidential address by Dr. A. S. Parkes to Section D (Zoology) discusses the biological effects of cold. This subject has attracted many of those prominent in the history of science, including Robert Boyle, Réaumur and Spallanzani. These early workers relied on natural conditions or simple freezing mixtures to obtain their effects, but they contrived to experiment with a wide variety of living cells and organisms. During the past century, the availability of solidified carbon dioxide and the liquid gases has enormously increased the range of temperatures over which experiments can be conducted, and naturally the range of experimental material has also been increased. At the outset we can distinguish two main branches of the subject: first, the study of the effect of cold on the whole organism, whether it be an insect or a man; and secondly, the study of the effect of cold on the isolated cells or tissues, or even whole organs of an organism. From our present point of view, what is important is the internal temperature of the cell, tissue or organism, the environmental temperature being of importance only in so far as it influences the internal temperature.

Cold-blooded animals allow their body temperature, within certain limits, to fluctuate in keeping with environmental temperature. Some of the lower cold-blooded animals, notably insects, have a remarkable tolerance for cold, not merely in the range of temperatures above zero but actually in a range well below zero. This tolerance appears to depend partly on a striking capacity for becoming supercooled and, in some instances, on the ability to withstand the crystallization of the body-water as ice. This tolerance of sub-zero body-temperature under natural conditions is not seen in the higher poikilotherms, and stories of fish and frogs frozen solid in blocks of ice are almost certainly apocryphal.

In contrast to cold-blooded animals, warm-blooded animals maintain a closely controlled body-temperature which is almost always between 37° C. and 41° C., and which in most parts of the world is much above environmental temperature. Some warm-blooded animals, however, hibernate during the winter, and in this state they take on many of the characteristics of cold-blooded animals. Non-hibernating warm-blooded animals were commonly supposed to die if body temperature was artificially reduced to a level at which heart-beat and respiration ceased. It is now known, however, that under laboratory conditions a warm-blooded animal such as a rat or a hamster can be resuscitated from deep body temperatures below zero. As the body-temperature goes below zero the animal either supercools or begins to freeze. The former process is comparatively benign; the latter has so far proved lethal when pushed to a stage at which more than 50 per cent of the body-water is converted to ice.

It is more easy to generalize about isolated cells and tissues. Among the invertebrates, certain cells survive being subjected to extreme cold, but almost all the normal cells and tissues of vertebrates are killed by freezing and thawing under ordinary conditions, and little progress was made in this field until it was discovered that certain substances, notably glycerol, protect cells and tissues against the otherwise fatal effects of freezing and thawing. By the use of glycerol it has been possible to freeze certain types of mammalian cells and tissues, especially spermatozoa, red blood cells, and endocrine tissues, and keep them at low or very low temperatures for long periods, and afterwards to thaw them out and use them effectively for insemination, transfusion or transplantation. It may be that further refinements of technique will make it possible to dry these cells from the frozen state and permit long-term storage at ordinary temperatures.

The study of the biological potentialities of low temperatures is at present one of the growing points of biology, and it is likely to contribute substantially to man's powers over Nature.

THE ATLANTIC ENDS OF EUROPE

THE presidential address by Prof. E. E. Evans to Section E (Geography) presents some results of researches into the origins of human settlement and the development of land use and social systems in the Atlantic fringe of Europe, with special reference to Highland Britain and Ireland. The environment of the Atlantic Ends is characterized by deeply indented coasts backed by infertile massifs of ancient rocks relieved by scattered patches of recent glacial or fluvial deposits. Climatically, the mild winters, heavy all-season precipitation and high values of wind and cloud have favoured pastoralism rather than arable farming. Consciousness of an Atlantic culture-area extending from Galicia to Norway was strongest in the early days of Christianity, by which time fishing and seafaring, extensive stock-rearing and restricted arable farming were well adapted to the three major elements of the environment. Independence, pride of blood and strong personal loyalties were characteristic features of society. The prevailing form of settlement was the joint farm or extended-family holding, a cluster of peasant homesteads possessing common rights in infield, outfield and mountain grazing. These house-clusters must be distinguished from the villages of the European plain, and it is suggested that they are a type of prehistoric settlement which persisted in the far west. Further, the Atlantic long houses, only one room wide, are similar in plan to those of neolithic Europe. It is argued that the system of co-operating kin-groups was maintained along the Atlantic in environments which called for common effort yet could be utilized without the technological equipment and complex organization of a manorial system. Early Indo-European institutions, reaching the west probably during the late Bronze Age, were absorbed and became fossilized.

Already in the third millennium B.C., shifting cultivators of the western Neolithic had reached the Atlantic Ends and tapped the fertility of forest soils with crops of wheat and barley. During the early Metal Age, when supplies of tin, copper and gold became commercial assets, the fringe experienced a golden age. In the sub-Boreal, dramatic environmental deterioration affected upland areas, where bogs replaced forest, following clearance by man and podsolization. The megalithic cult had been widely adopted and the great stone monuments, the abodes of powerful ancestral spirits, became symbols of a lost fertility.

After the introduction of oats and other innovations in the Early Iron Age, a readjustment allowed a second blossoming-period in the sixth to ninth cen-

turies, and a third phase of expanding food resources and population followed the coming of the potato. With the enclosure movement and the scattering of farms, commercial agriculture came to be based on the old outfield practice of 'taking the plough round the farm' by using long leys.

Within the British Isles, the Atlantic inheritance had made a distinctive contribution to British life, and to overseas lands through heavy emigration, and Prof. Evans makes a plea for the preservation of regional variety in a world weighted in favour of uniformity. There is a danger that movements towards the restoration of self-government will lead to isolation. Along the Atlantic shores, peasant attitudes of immemorial antiquity have not entirely succumbed to the impact of a money economy. Idealization of the past and a reverence for spiritual values, coupled with suspicion of impersonal external authority, have sprung from the experience of living in the Atlantic Ends.

BRITISH ECONOMY UNDER INFLATION

PROF. A. J. BROWN, in his presidential address to Section F (Economics), states that the outstanding feature of the British economy since the War has been the low level of unemployment in comparison with both pre-war experience and the most sanguine war-time expectations. This low level appears to be explained in part by an alteration in the behaviour of employers. It is noteworthy that variations since the War have been mostly in hours of work or, secondarily, in the number of people available for employment, whereas before the War they took place mainly in the proportion of the labour force unemployed.

The great cause of high and steady employment since the War has, of course, been freedom from fluctuations in demand. Most of all, we have been remarkably free from any major fluctuations in world demand for our goods and services. There has, however, been a very marked fluctuation in internal demand for inventories, which may be a new phenomenon in Britain, though it is well known in the United States, and which might have been expected to produce marked fluctuations in employment such as have occurred in America.

The main reason why Britain has escaped these fluctuations in employment is that variation in demand for inventories has been largely taken up by variation in imports, but the method of financing government expenditure has helped somewhat and there has been fortuitous assistance from variations in defence expenditure and also from variations in the prices of our imports.

The question arises whether the high level of employment has diminished the adaptability of the economy. A simple measurement of the amount of change in the British economic structure in the years 1948–56 shows it, in fact, to have been almost identical with that experienced in the years 1929–37 (the amount of change in the intervening period 1937–48 having been about twice as great). It is natural to inquire further whether this adaptation to economic forces since the War has taken place by a different market mechanism from that of the 1930's. It proves to be the case that, on the whole, the industries which expanded relatively to the rest in the 1930's were not those in which earnings rose most. On the other hand, there is a definite tendency for the industries which have expanded most since 1948 to have obtained their increased share of the labour force by raising their earnings in relation to others.

The record of progress in Britain in regard to the standard of living since the War has been good by previous standards but not striking in comparison with other countries. It is very difficult to find any close connexion between this progress and the timing of new investment; in fact, in manufacturing industries especially, the striking feature of the past ten years has been the increase of output in relation to both labour and capital.

The amount of saving (and hence of investment) in the economy does not seem to have been adversely affected to any marked degree by post-war inflation. Such reduction as there has been in it after allowance is made for the level of disposable real income does not seem too great to be accounted for largely by change in distribution of income. A further indication that our inflationary experience is not likely seriously to have affected saving is that there is little sign in the prices of assets or in the level of interest-rate in relation to money holdings that steady expectations of rise in prices have had much influence. It may be concluded that Britain's record of high employment and economic progress since the War has been reasonably satisfactory in many ways, but that a considerable part of our success is due to external circumstances which may change and with which we may not have adequately equipped ourselves to deal.

HEAT AND THE ENGINEER

PROF. O. A. SAUNDERS, in his presidential address to Section G (Engineering), comments that in pursuing his art the engineer must always encounter many problems of heat and heat transfer. These occur in the generation of power from heat, in the control of heat-influenced processes, and in many problems of engineering design where the production of heat is a nuisance. In the field of power generation, interest is increasing in the direct conversion of heat into electricity by some form of thermionic converter which would allow the elimination of expensive turbo-alternator machinery, and would have many applications for small generating sets even though the thermal efficiency were not high. The possibility of direct conversion of nuclear energy into electricity, although remote at present, would have far-reaching effects on power stations of the future.

The engineer is vitally interested in progress of the fundamental science of heat transfer, which has advanced greatly during recent years. By the use of numerical methods and computing machines, it is now possible to solve many problems theoretically, and the field of laminar flow convection is now well covered. For turbulent flows, however, where the greatest practical interest lies, empirical methods are still needed, although the understanding of these flows has improved. The gas-cooled nuclear power reactor has posed some interesting problems of turbulent-flow heat-transfer, and their solution is of great practical importance.

The regenerator is an attractive principle of heat exchange, and new ideas for rotary regenerators have come forward in recent years; but it is difficult to design a satisfactory mechanical arrangement,

especially for the moving seal between the two fluids. The prospects of the gas turbine for automobiles and other mobile applications would be transformed if a reliable and efficient regenerator could be developed.

The problems of aerodynamic heating have been increasingly felt in high-speed aircraft and missile design, and novel means of overcoming them have been put forward, including sublimation of the surface layer of the material in the case of missiles and the use of cold fuels such as liquid hydrogen for supersonic aircraft. There are many other interesting new lines of research and development in industrial heat transfer. The dropwise condensation of vapours, which would give a useful reduction in size of power station steam condensers, has been successfully promoted chemically for copper-alloy tubes, but for stainless steel surfaces such as are used in condensing organic vapours it has not so far been possible to find a promoter which will adhere satisfactorily. The control of radiation from luminous furnace flames has been improved by research on large-scale furnaces, and, for example, the use of pitch creosote to control and improve the relation from non-luminous coke over gas flame has been successfully worked out.

In electrical engineering, the use of hydrogen, especially at elevated pressure, for cooling turbo-alternators, has been the biggest factor in improving the performance of machines and has made possible the increase of the output of the single unit from 200 to 350 megawatts. Liquid metals as heat carriers have received special attention from the nuclear reactor designers because of the favourable neutron-capture properties of sodium and potassium and their alloys and because of their high rates of heat transfer. It is likely that these metals will find new uses outside the nuclear field now that handling problems are being overcome.

Creative research, inventive development, inspired design and novel construction in the field of heat transfer are all needed to keep pace with the needs of modern technology.

THE STUDY OF FOLK LIFE AND ITS PART IN THE DEFENCE OF CIVILIZATION

IN his presidential address to Section H (Anthropology and Archæology), Dr. Iorwerth C. Peate points out that anthropology—the science of man—is a vast field of which folk life, like archæology, is a small corner. The change of the title of Section H in 1947 from "Anthropology" to "Anthropology and Archæology" is to be deprecated, since anthropology is a large enough umbrella for us all. The student of folk life is concerned with the study of every stratum in the community, and with all communities except those completely affected by a high degree of industrialization.

Folk life as a field of research has developed from the study of collections of 'bygones' in museums, and it is therefore often believed, erroneously, that it is concerned only with the post-medieval period. There is no date-line at which the study begins. Nor can it be said to end with the Industrial Revolution, for even in communities affected in part by industrialization, much evidence remains of the persistence of traditional ways of life. The traditional cultural pattern, from its early beginnings to the present day, is the basis of study.

Pioneer work in the Scandinavian countries, particularly the work of Dr. Sigurd Erixon, the late Åke Campbell and the late Wilhelm von Sydow, established the standard by which most work on the subject must be judged. Certain aspects of the study may be mentioned. (*a*) The study of houses. Most major works on English architecture are of little use in the study of folk life, for they ignore the smaller buildings such as farmhouse and cottage. Regional studies such as Fox and Raglan's "Monmouthshire Houses" are urgently needed before any interpretative work can be carried out. (*b*) Similar records are required for problems such as transhumance. (*c*) The student of folk life should be chary of accepting uncritically such theories as those of a time-lag in fashion in areas far removed from a metropolis or of national forms of costume—theories which are based on insufficient evidence and basically unsound.

The study of folk life cannot be confined merely to visual materials. Speech and local dialects are an important part of it: vocabularies of the hearth and home, those relating to domestic animals, agriculture, festivals, religion and all social activities. The work on oral traditions carried out in England, Scotland and Wales should, Dr. Peate believes, be financed by the State. The refusal by the State to give an emergency grant to record the traditions of North and South Uist is thoroughly to be deplored.

We study the eternal task of 'building up a civilization in Nature' in all the little nations of Europe. Their traditions are the buffer between the passive barbarism of the West and the active barbarism of Eastern Europe, between two world forces which threaten to reduce the world to the level of brute sensation. The study of folk life has, therefore, a purpose beyond the mere limits of an academic discipline: not only does it contribute to the sum of scientific knowledge but also it assists in the rehabilitation of a degraded civilization.

SOME ASPECTS OF CELLULAR DIFFERENTIATION

DR. E. N. WILLMER, president of Section I (Physiology), comments that the manner in which the cells of a highly developed organism such as man differentiate is not a problem which can ever be solved by the study of that organism alone. For example, in human embryology there comes a time when certain connective tissue cells, the fibroblasts, begin to produce collagen and form an inter-cellular fibrous matrix. The problem of the formation of these fibres was not, however, first solved for man; its solution must have already been achieved many millions of years ago when the calcareous sponges were first evolved, for they, like the majority of animals in all groups, form a ground-substance with collagen fibres.

It may therefore be more profitable to investigate the collagen-forming cells when they first appear, as, for example, in sponge embryos, than to study them only in what may be a specialized form in man. In the embryos of calcareous sponges, the fibre-forming cells originate from the flagellated cells which constitute the animal pole of the embryo. The posterior

amœboid cells do not apparently contribute. An investigation of the difference between these two types of cell may therefore yield information about the original conditions which led to the production of fibres. At an even more primitive level, study of an amœba (*Naegleria*), which shows dimorphism, in that it may exist in either an amœboid or a flagellate form according to the ionic concentration of its surroundings, emphasizes the influence of the ionic environment on cell form. It perhaps also suggests the possibility that the anterior and flagellate cells of the sponge may react in one way to their ionic environment while the posterior amœboid cells react in an opposite manner, and that the two types of cells are combined in one embryo in such a way as to maintain the ionic stability of the organism as a whole.

The further possibility that, since the fibre-forming cells of the sponge are formed from the flagellate cells of the embryo, the mucoproteins and fibres (or their precursors) are in some way related to the maintenance of ionic equilibrium by the cells seems to be one worth considering. The suggestion is therefore made that the preservation of ionic equilibrium by a cell may involve the production of certain metabolic by-products; for example, hexosamines or related substances from which mucoproteins and mucopolysaccharides can be built on one hand, and glutamic acid, proline, or hydroxyproline from which collagen fibres can be synthesized on the other. A cell which is moving cations across its membrane in one direction may perhaps drive these by-products in the other direction. Some cells derived from the flagellate cells (for example, fibroblasts) would thus be in a strong position for forming intercellular matrices, because they normally liberate the necessary precursors, whereas other cells, for example, those corresponding to the amœboid cells, would be more likely to store the mucoproteins within their cytoplasm and have to turn the glutamic acid, proline, etc., to other uses within the cell.

This is certainly an over-simplification of the position, but it may serve to illustrate a general principle. It may therefore be more profitable to tackle cellular differentiation from rather more basic premises, and to study the origin of the simplest colonial forms, for it was they who were the first to solve the problems of cell adhesion, of ionic and osmotic balance, and of mechanical stability. If it could be discovered how they achieved these ends, and how their cells became differentiated accordingly, then the mutual relationships of cells, in higher organisms, and the influence of hormones and 'organizers' upon them, might be made somewhat more easily intelligible.

SOME PROBLEMS OF COLOUR VISION AND COLOUR BLINDNESS

THE presidential address to Section J (Psychology), by Prof. R. W. Pickford, marks the jubilee of psychological studies in Glasgow, for the lectureship in general and experimental psychology in the University of Glasgow was established by the University Court in 1907, and H. J. Watt, the first lecturer, began his duties in 1908. The Laboratory of Experimental Psychology was established in part with a donation in 1908, and a gift of auditory apparatus from his collection, by friends of Prof. John G. McKendrick, formerly professor of physiology in the University of Glasgow.

The history of colour blindness tests has shown a number of interesting developments, from the use of coloured wools by Holmgren, to Edridge-Green's lantern, beads and spectrometer, and other and better lantern tests have been devised, notably by Giles. The most popular tests of colour blindness have been pseudo-isochromatic charts and tables, such as the Stilling, Ishihara and other tests. Farnsworth's and Dimmick's tests are great improvements upon them.

The Rayleigh equation of a mixture of lithium red and thallium green, matched against a standard of sodium yellow, has led to the Nagel anomaloscope, which uses spectral lights, and to several other kinds of anomaloscope, which are mostly filter instruments. Similar equations, especially of blue and yellow, or of blue and green, have been utilized as tests for blue and yellow vision.

The results of anomaloscope tests show an instructive grouping of colour-vision defects and variations, depending on combinations of variability of matching range, deviation of mid-matching point and shortening of the red or violet end of the spectrum. There are two main types of red–green blindness: (1) protan defects, including protanomaly, extreme protanomaly and dichromatic protanopia; (2) deutan defects, including deuteranomaly, extreme deuteranomaly and dichromatic deuteranopia. In addition, there are tritanopic defects, or yellow–blue blindness, and minor forms of variation along the lines of the protan, deutan and tritan defects. Total colour blindness should also be mentioned.

Red–green blindness is a sex-linked Mendelian recessive character, found in about 7·5 per cent of men in Britain. It shows interesting variations of frequency in different geographical areas and racial groups, the lowest percentage reported among men being 0·5 per cent in Fiji by Geddes, and the highest probably being 12·8 per cent among Toda men by Rivers. Co-ordination of testing standards is not easy. Yellow–blue minor defects are more frequent among dark-skinned peoples, but red–green defects are less frequent among them than among whites.

It is generally agreed now that there must be two series of major red–green defective genes, with separate loci on the *X*-chromosome, and about three alternative forms in each series, in accordance with the classification given above. A woman may inherit two types of defective gene, one from each parent and from different series, and yet have apparently normal colour vision. In certain cases of sex reversal, as in Klinefelter's and Turner's syndromes, in which the individual has developed sex organs contrary to the 'genetic sex', the frequency and pattern of inheritance of colour blindness is that expected for the 'genetic sex' rather than for the masculine or feminine phenotypes. For example, in an interesting pedigree there is a male 'woman' of the type found in Turner's syndrome, who must have inherited her colour blindness from her mother, for her father has normal colour vision. Colour blindness is an incomplete recessive, since women heterozygous for it show minor defects more frequently than normal homozygous women.

Colour blindness requires three general hypotheses to explain its nature and variations: (1) the 'loss' hypothesis, which assumes the absence of certain functions or sensory end-organs; (2) the 'collapse' hypothesis, which assumes the failure of certain

functions to differentiate groups of light waves normally distinguished; and (3) the 'swing' hypothesis, which assumes variations in the distribution of sensitivities which may otherwise be normal. It seems that protanopia is a loss defect, deuteranopia is a collapse defect and that the various types of anomalous colour vision are due to swing defects either alone or in combination with one, or both, of the others. The whole subject is extremely complex.

The most favoured theory of colour vision is still the trichromatic theory due to Young and Helmholtz, but there have been many advocates of others, notably polychromatic theories and the four-colour theory due to Hering. At present, it seems that the trichromatic theory would be adequate to account for all forms and variations of colour vision and its defects, provided that we are allowed to introduce the concept of swing defects.

The studies of colour vision defects and of tests for their detection and measurement are of the greatest importance, especially where life and safety depend on the use of colour signals, and also in those industries in which fine colour discrimination and judgment are required.

THE CAPE AS AN ANCIENT AFRICAN FLORA

THE presidential address to Section K (Botany) by Prof. R. S. Adamson points out that the so-called Cape flora is a very distinctive one in Africa which has its main development in a small area in the extreme south-west of the continent. The flora is a very rich one with a high proportion of endemics, and is made up of portions with different geographical relationships.

Though this flora in its typical form is confined to the south-west corner, there are distinct traces of it in other regions, notably on the higher mountains throughout the continent, and also to a lesser extent in the Mediterranean flora of the north coast of Africa. The floras of the adjacent islands, Madagascar and the Atlantic Islands also show clear affinities. All appear as old floras and floras with a common origin.

Though the Cape region is the largest and much the richest of the portions existing, it is not suggested that it was the source from which the others arose. Instead, the portions are regarded as being remnants of the area of a once widespread flora that covered the more temperate parts of the continent. Changes of climate and of geography have resulted in the disappearance of the flora in the intervening areas. The original flora must have existed at a time when islands such as Madagascar were united to the mainland.

The existing parts have undergone development and change since their establishment, especially in the Cape region, where the area is largest and conditions have remained favourable.

In attempting to trace the possible origin of this old flora, its close relationships with those existing in south and south-west Australia and in the south-west of South America are noted. The most probable explanation is found in the theory of continental drift. The old flora was one that became established when there were land connexions. Those existing to-day are the descendants of the separated parts, each of which has become modified by local developments and by immigration from adjacent regions.

THE PARTNERSHIP BETWEEN INDUSTRY AND EDUCATION

SIR WILLIS JACKSON says in his presidential address to Section L (Education) that he would like to interpret his selection as president of the Section as a recognition of the importance which is attached to the place of industry in the educational structure of Britain. It affords him the opportunity of paying tribute to the considerable educational service which is being performed by many industrial concerns, and to the part they have played towards establishing within the schools a belief that industry can offer to those with a sense of vocation as satisfying a career as the 'learned' professions which have traditionally attracted a dominant proportion of our most able young people. The increasing number now devoting themselves to a prolonged study of science and technology means more than a mere recognition of the material importance of scientific and technological achievement, and more than a growing acceptance that scientific subjects, properly taught, are no more specialized than, and provide as good a vehicle of education as, arts subjects. It means that industry is coming to be seen not merely in terms of machines and technical processes but also of men of character and stature; and that it provides great opportunities not only for the exercise of scientific and technological skill but also for co-operation in service and in human relations.

Sir Willis Jackson also makes forthright comment on the fact that the contribution of very many other firms towards the further education and the practical training of their juvenile recruits is much less than is demanded both by their own best interests and by the well-being of the country as a whole. He refers to the increase since the War in the willingness of industry to release its young employees to attend day-time technical courses, but also to the wide discrepancies which exist between different branches of industry and to the enormous scope for further improvement. His main anxiety, however, concerns the dearth of satisfactory facilities for apprentice training at all levels, which, unless corrected as a matter of urgency, is likely to frustrate the developments now taking place within the schools, technical colleges and universities of Britain, and to produce a serious national situation when much increased numbers of young people become available for employment in the early 1960's. After outlining the comprehensive training schemes organized by some large industrial concerns, he advocates a considerable expansion of co-operative arrangements among groups of small and medium-sized firms. In his opinion, however, these will develop too slowly if left to the initiative of industry alone, and that in any event the time has come when the national interest requires independent assessment of the adequacy and effectiveness of present-day concepts of apprentice training. So far as graduate and student apprentices are concerned, there are at least signs of machinery, within some of the professional institutions and within the National Council for Technological Awards, by which advice may be given and appropriate pressures may be applied. But even these do not exist in respect of the nationally no less important spheres of technician and craft training. He compares the caution of the recent Carr Committee report on "Training for Skill" with the forthright recommendation in the 1944 report of a conference of representatives nominated by the Manchester and

District Committees of the Engineering and Allied Employers National Federation, the Amalgamated Engineering Union, the major engineering institutions and the Regional Advisory Council for Technical and other Forms of Further Education, that a National Apprentice Council and associated regional councils should be established, and that their directing activities should be supported by a national fund provided jointly by the State, the local education authorities, and the employers and trade unions concerned.

After referring to the serious shortage of science and technical teachers, Sir Willis says that the more effectively industry fulfils its responsibilities in the fields of education and training the fuller will be the benefit which will accrue to it—employer and employee alike—and through it to the nation.

DIGESTION IN THE RUMINANT

IN his presidential address to Section M (Agriculture) Dr. D. P. Cuthbertson points out that the outstanding difference between the ruminant and other herbivores is that the former pre-ferment their food through microbial action in the first two compartments of the complex stomach—the reticulo-rumen sac—before digestion by enzymes secreted by the digestive glands begins in the abomasum or fourth stomach. Considerable absorption of the soluble products of microbial activity takes place from this sac. In the third compartment, the omasum, absorption of water is the main feature.

The reticulo-rumen sac thus forms a fermentation vat in which bacteria and protozoa are established under highly reducing conditions when the animal is quite young. Fermentation of cellulose through microbial activity takes place there; otherwise it would be unavailable through lack of a cellulase in the digestive glands. In grass itself, and especially in root crops, other fermentable carbohydrates exceed cellulose in amount and being more soluble and less resistant structurally and mechanically than cellulose, are more readily fermentable by a much wider variety of micro-organisms, but not necessarily to the same ratio of desired products.

The reticulo-rumen sac is never empty, and constitutes a functional field in which all the activities are organized for utilization of microbial products and all factors therein make for a steady state. The activity of the salivary glands, the process of rumination involving re-mastication, the absorption of the products of microbial activity and the interchange of ions between rumen contents and blood—in the case of sodium against the concentration gradient—all contribute to the continuity of microbial action during the whole life of the animal, and produce conditions which one can scarcely hope to reproduce *in vitro*. Nevertheless, by observation of the micro-organisms—the bacteria and the protozoa—at the site of their attack on food particles, and in isolation in culture, and by a study of the soluble products of fermentation and their absorption, much information about this microcosm has been obtained.

Consideration is also given by Dr. Cuthbertson to the early development of the ruminant: to the role of the saliva, and to the passage of food through the alimentary tract.

In the rumen, dietary protein is subjected to fairly vigorous hydrolytic conditions, and the low-molecular products, including amino-acids, are then assimilated by micro-organisms and incorporated into their body protein or, if amino-acids accumulate in excessive amounts, the micro-organisms acquire the power to ferment them deaminatively to ammonia, short-chain fatty acids and carbon dioxide. Further, it is known that urea and ammonia can also be utilized by the micro-organisms for elaboration of their own body proteins. These proteins are of good biological value and are presumed to be digested in the abomasum and small intestine in similar fashion to that taking place in the non-ruminant.

When cellulose and starch are broken down by the micro-organisms to soluble sugars, these, like other soluble sugars in the diet, are fermented to give short-chain fatty acids. These acids, together with those derived from protein, are absorbed from the rumen into the blood stream. It has been calculated that for hay-fed sheep, about 70 per cent of the total energy requirements is provided by these fatty acids. These short-chain acids are quantitatively much more important than glucose as a source of energy.

While the microbiological synthesis of fat-soluble vitamins (other than vitamin K) has not yet been unequivocally demonstrated, the metabolic needs for the various B vitamins are met by synthesis in the reticulo-rumen through microbial activity. The synthesis of vitamin B_{12} is conditioned by the cobalt content of the feed. Ascorbic acid appears to be synthesized in the ruminant's own tissues.

This pre-gastric microbial digestion confers important benefits upon the ruminant. Energy from fibrous foods, which could not otherwise be obtained, is more efficiently garnered and the available energy is yielded over a longer period of time, so that the animal is more resistant to periods of starvation; the uptake of nitrogen is controlled and that from non-protein sources utilized more efficiently via microbial proteins; and considerable synthesis of vitamins takes place. This aspect of the physiology is as fascinating to the investigator as it is important for the husbandman. Further advances should help to clear our understanding of some of the so-called 'metabolic' diseases.

THE CULTURAL VALUE OF LOCAL SOCIETIES

LORD BOYD-ORR, in his presidential address to Section X (Assembly of Corresponding Societies), remarks that though all governments are clamouring for more science, human society is suffering acute indigestion from an overdose of science. For example, it is estimated that in a third world war with the weapons we already have, 90 per cent of the people in the northern hemisphere would be wiped out. One would have thought that that was plenty to be going on with, yet in government 'hush-hush' laboratories there is probably more research to improve weapons of war than in any other field.

In industry, science has increased the output per man and the total capacity for production to such an extent that although a large part of industrial potential is engaged in producing armaments, factories produce goods for peaceful uses faster than they can be dispersed and consumed, so that production has to be slowed down with resulting unemployment which, in the United States where tech-

nology is most advanced, at present exceeds five million. To find work for people is now a major domestic political problem. But science still advances. It is estimated that when automation and other improvements foreshadowed are applied, one man will be able to produce as much as four or five at present.

Equally great is the advance in biological science. Where modern medicine has been applied, the expectation of life at birth has increased by twenty years since 1900. It is now being applied in all countries and in forty years the present population of the world is likely to be doubled, and doubled again in the succeeding thirty years. Yet medical research is being intensified—and rightly so. But too little thought is being given to how long the Earth will be able to support its human inhabitants.

Thus, in one generation, the advance of science has made war obsolete unless, of course, our civilization lacks the intelligence to avoid committing suicide. It has lifted the burden of labour from man's shoulders and changed scarcity, with inevitable poverty, for the majority of the people in the world to one of potential abundance for all mankind. It has made it possible to free the human family from most of the suffering and premature death which has afflicted it since man first appeared on the Earth.

What is needed to-day is, not more science, but changes in the structure of society to enable people to enjoy the rich fruits science has already made available. Governments—even to some extent, totalitarian governments—cannot bring about big changes until people realize the need for them. The British Association, especially by its presidential addresses, is doing much to enlighten the public on the powers of science and the problems they have created. It is suggested that this should now be its main function.

Several sections might consider common big issues and report their findings in non-technical language. Section X, which consists of about 170 allied societies the members of which represent the more intelligent part of the population of Britain, might consider the changes needed to adjust society to the new atomic age. By doing this it would promote knowledge, wisdom and benevolence, or in other words 'culture', which this scientific age so sadly lacks.

The British Association can perform an even more valuable ervice than it has done in the past by adapting its meetings to throw the searchlight of science on world affairs.

THE GLASGOW REGION

The Glasgow Region

A General Survey. Edited by Prof. Ronald Miller and Dr. Joy Tivy. Pp. xix+325+20 plates. (Glasgow: Local Committee of the British Association for the Advancement of Science, 1958.)

WHILE it can scarcely be said that the various centres visited by the British Association vie with one another in the production of a handbook to the neighbourhood, the local committees have certainly succeeded in producing a valuable series of books, impressive both in quality and in size. The handbook for the Glasgow meeting is no exception. It is a very substantial volume, well supplied with plates and other illustrations, and embellished with the University and City arms on the covers.

The volume has been prepared under the editorship of Prof. Ronald Miller and Dr. Joy Tivy, of the Department of Geography in the University of Glasgow, who emphasize in the foreword that it has to serve a double purpose: it must introduce the region to the visitor and it must give the local reader food for thought, thus providing for both divisions of the British Association membership. This they have succeeded in doing, mainly by means of a series of chapters surveying different aspects of the scene.

Prof. Miller opens with a chapter on the geography of the region. This is followed, quite naturally, by a résumé of the geology by Prof. T. Neville George. C. A. Halstead deals with the climatology. The chapter on land utilization is divided into three parts, written by Prof. John Walton (vegetation), Prof. Donald S. Hendrie (agriculture) and J. E. James (forestry) respectively. Biology of the Clyde and its associated waters is dealt with by Dr. W. D. Russell Hunter, who also provides some notes on the land animals of the area. The Clyde in prehistory and in the Roman period is discussed by Dr. Horace Fairhurst and Dr. Anne S. Robertson respectively. Chapters on Glasgow itself and its history to 1750 (Prof. George S. Pryde) and the industrial and commercial developments (John B. S. Gilfillan and H. A. Moisley) bring the story to 1914. There follow chapters on the engineering industries (Drs. James Orr and Sarah C. Orr), fuel and power (Dr. R. Common on coal and gas, and D. R. Diamond on electricity and petroleum) and the economy of Glasgow (Prof. Alec Cairncross). Human problems are the subject of chapters on population distribution (Dr. Joy Tivy), the Glasgow overspill problem (Berenice D. Baker), transport (John F. Sleeman) and Glasgow's spheres of influence as a regional capital (H. A. Moisley). The histories of the University of Glasgow and of the Royal College of Science and Technology are briefly summarized by Prof. John D. Mackie and Charles G. Wood respectively, A. McLaren Young surveys the fine arts and Catherine B. Smith provides brief notes on research institutions in the area.

"The Glasgow Region" is a worthy addition to the series of handbooks prepared by the enthusiastic and hard-worked local committees in the cities visited by the British Association. For the teacher of geography they are veritable mines of information, up to date and authoritative, for regional studies; for the visiting member of the British Association they are equally useful for reference purposes, and also as reminders of many interesting and valuable occasions. There is no index.

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY, GLASGOW

NEW ENGINEERING BLOCK

IN the years between the two world wars, the engineering department of the Royal Technical College, Glasgow, established an international reputation for teaching and research. It seems appropriate, therefore, that the recently completed first phase of a long-term scheme of development of the College which, since 1956, has been called the Royal College of Science and Technology, should be a new building for engineering. The College is one of the leading technological institutions in Britain selected for major expansion in accordance with the national plan for higher technological education. It has been affiliated to the University of Glasgow for some forty-five years and was recognized as a university college in 1919.

The new building accommodates the Department of Mechanical, Civil and Chemical Engineering and the Department of Mining. It is a seven-story building adjoining the older buildings of the College. The laboratories containing heavy equipment are housed on the ground floor, which extends beyond the line of the upper floors. Smaller teaching and research laboratories occupy the first floor. The second floor accommodates fourteen rooms which can be used as lecture rooms, small laboratories or research rooms, as required. The Mining Department occupies the whole of the third floor and, in addition, has a laboratory in the basement of the building. The main lecture rooms are on the fourth floor and are eight in number; one of them is specially equipped for general lectures and society meetings. On the fifth floor there are eight drawing and design offices, and on the sixth floor there are staff rooms and central offices. The floor area of each of these floors above the first is approximately 12,500 sq. ft., excluding the space occupied by the lift and main stairway.

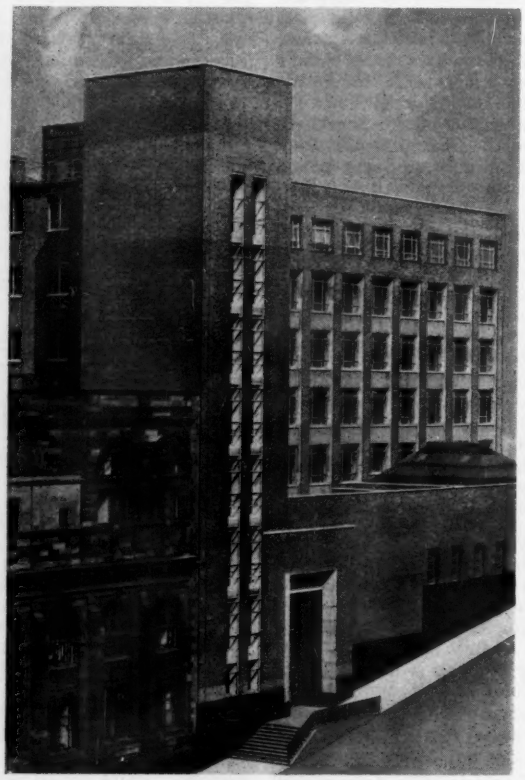

Fig. 1. The New Engineering Block

The eight large laboratories on the ground floor are equipped for teaching and research work in connexion with hydraulic structures and concrete, hydraulic machines, static testing of materials and components (loads up to 250 tons), dynamic testing of materials and components together with hardness testing and the compression testing of masonry, production engineering, aerodynamics, machine dynamics and heat engines, respectively. Thus, the production engineering or machine tool laboratory contains a variety of modern machine tools such as lathes, milling machines and grinding machines. The equipment of the aerodynamics laboratory includes wind tunnels, while that of the machine or technical dynamics laboratory includes electrical and hydraulic servo mechanisms and an analogue computer, in addition to equipment for studying vibrations and balancing of machinery. Smaller laboratories on the first and second floors are equipped for advanced teaching and research in soil mechanics, theory of structures and experimental stress analysis, chemical engineering and metrology, as well as for teaching elementary mechanics of machines, dynamics, statics and strength of materials and hydraulics.

A variety of research projects is being conducted in the laboratories, and facilities are provided to enable students to work for higher degrees. Notable among the research activities are: hydraulic studies using scale models, contact pressure on foundations, non-destructive testing of concrete, circulation in water-tube boilers, transportation of solids by fluids, corrosion fatigue of steel in sea-water, load-carrying capacity of thin-walled structures, behaviour of shell structures, transients in heat transfer and cutting tool action. Sponsors of research projects include the British Shipbuilding Research Association, the Cold Rolled Sections Association, the North of Scotland Hydro-electric Board and the Ministry of Supply. Research in the Mining Department includes a mine ventilation project and a subsidence project sponsored by the National Coal Board.

In addition to four-year undergraduate courses, the Department of Mechanical, Civil and Chemical Engineering provides one-year and evening post-graduate courses for practising engineers, the subjects of which include nuclear power, production engineering, structural engineering and environmental control engineering.

(*Continued from page* 572)

It was observed that injuries to the brain of the graft as well as the host were far more serious than in homografts; they deserve careful study in both cases, but especially in homografts, because some of the grafted chicks hatch. Deformities and imperfections affecting the upper jaw were also quite common. This particularly applies to the duck-to-chicken transplants, where an under-developed or even vestigial upper bill was a regular occurrence. Deficiencies in the cartilage and bone-forming tissues were pronounced and resulted in an incomplete skull. Another interesting observation is that incubation periods lasting several days more than the normal were recorded. Thus the incubation period of one grafted chicken embryo lasted for 26 days and of a duck embryo for 33 days; both embryos showed a considerable lag in development.

PETAR N. MARTINOVITCH
Boris Kidrič Institute for Nuclear Sciences
Post. Fah 522,
Belgrade.
April 11.

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SYNTHESIS OF DEOXYRIBONUCLEIC ACID IN EXTRACTS OF MAMMALIAN CELLS

By PROF. J. N. DAVIDSON, DR. R. M. S. SMELLIE, DR. H. M. KEIR and A. HOPE McARDLE
Department of Biochemistry, University of Glasgow

STUDIES on the incorporation of radioactive precursors, such as ^{14}C-formate, ^{14}C-adenine and ^{32}P-phosphate, have shown that Ehrlich mouse ascites tumour cells can synthesize deoxyribonucleic acid under *in vitro* conditions[1]. A more specific precursor of deoxyribonucleic acid, however, is thymidine, which in the form of ^{15}N-thymidine[2], or ^{14}C-thymidine[3], has been shown to be incorporated readily into deoxyribonucleic acid in the rat[2], the chick embryo[3], bone marrow cells[4], isolated thymus nuclei[4], onion root tips[5], and tissue cultures[6]. With the production of thymidine labelled with tritium[7], a new tool has become available for the study of the biosynthesis of deoxyribonucleic acid, and tritiated thymidine has been used by several groups of workers both in the study of chromosome reproduction[7,8] and in the investigation of the formation of deoxyribonucleic acid in regenerating rat liver[9].

Tritiated thymidine obtained from Schwarz Laboratories, Inc., was added to a suspension of Ehrlich ascites tumour cells incubated *in vitro* for 2 hr. in ascitic fluid and the cells processed by methods previously employed[1]. The deoxyribonucleic acid-protein precipitated by perchloric acid from the alkaline digest was treated with 0·5 *N* perchloric acid at 70° for 20 min. to extract the deoxyribonucleic acid, and the extract, after neutralization with potassium hydroxide and removal of potassium perchlorate, was used for determination of deoxyribonucleic acid by measurement of the extinction at 268 mμ in the Beckman spectrophotometer and for assay of tritium in a windowless flow counter.

The tumour cells incorporate (4-^{3}H) thymidine readily into the deoxyribonucleic acid (Table 1). When the cells (including the nuclei) are disrupted in 0·25 *M* sucrose-phosphate buffer by means of an ultrasonic generator[10] the suspension of cellular debris still shows good, though diminished, incorporation. On centrifugation of this material, higher activity is found in the supernatant fluid than in the sediment, and the high activity of the supernatant fluid persists after all particulate matter has been removed by high-speed centrifugation ('Spinco' ultracentrifuge) at 105,000 *g* (Table 1).

Although we have used mainly a buffered solution containing 0·25 *M* sucrose and 0·1 *M* phosphate for the preparation of extracts of disrupted cells, other buffers such as Krebs–Ringer phosphate[11] or simple 0·1 *M* phosphate buffer with added magnesium chloride are also effective. The optimum *p*H is in the region of 8.

Table 1. INCORPORATION OF (4-^{3}H) THYMIDINE INTO THE DEOXYRIBONUCLEIC ACID OF INTACT AND SONICALLY DISRUPTED PREPARATIONS OF EHRLICH ASCITES TUMOUR CELLS

The incubations were, for 2 hr., in a medium containing 0·25 *M* sucrose, 0·1 *M* phosphate buffer *p*H 7·4, 2·5 μmoles/ml. adenosine triphosphate, 2·5 μmoles/ml. diphosphopyridine nucleotide, 50 μmoles/ml. glucose 2 μc./ml. (4-^{3}H) thymidine, 4 μmole/ml. magnesium chloride and, 20 μmole/ml. sodium chloride

Fraction	Specific activity of deoxyribonucleic acid (counts/min./μmole deoxyribonucleic acid-phosphorus)
Intact ascites cells	9,700
Sonically disrupted cells	600
Supernatant fraction (1,000 *g*) from disrupted cells	1,225
Sediment	322
Supernatant fraction after high-speed centrifugation (105,000 *g*)	1,661

For good incorporation of ^{3}H-thymidine into deoxyribonucleic acid, adenosine triphosphate, diphosphopyridine nucleotide and glucose are necessary (Table 2). Adenosine triphosphate and diphosphopyridine nucleotide produce their maximum effect at concentrations not less than 2·5 μmoles/ml., while glucose is most effective at the relatively high concentration of 50 μmoles/ml. It may be replaced by other energy sources such as hexose diphosphate, but not by pyruvate or glutamate.

Table 2. INCORPORATION OF (4-^{3}H) THYMIDINE INTO THE DEOXYRIBONUCLEIC ACID OF A PARTICLE-FREE EXTRACT OF DISRUPTED ASCITES CELLS IN 0·1 *M* PHOSPHATE BUFFER *p*H 8 CONTAINING 4 μMOLES/ML. MAGNESIUM CHLORIDE, 20 μMOLES/ML. SODIUM CHLORIDE AND 4 μC./ML. (4-^{3}H) THYMIDINE

Additions to extract (μmole/ml.)			Specific activity of deoxyribonucleic acid (counts/min./μmole deoxyribonucleic acid-phosphorus)
Adenosine triphosphate	Diphosphopyridine nucleotide	Glucose	
2·5	2·5	50	8,230
0	2·5	50	262
2·5	0	50	1,550
2·5	2·5	0	1,700

Other tissues, such as chick embryo, on sonic disruption in sucrose–phosphate buffer also yield active extracts, but none has proved so effective as ascites cells. Examination of cell-free extracts from a series of rabbit tissues disrupted sonically shows that the potency of an extract varies according to the mitotic activity of the tissue from which it is derived (Table 3). These extracts have been obtained by the complete disruption of the cells, including the nuclei. A potent extract of chick embryo has also been obtained by gently homogenizing chick embryonic tissue in sucrose–phosphate buffer, centrifuging down the cell debris, including the nuclei, and subjecting the supernatant fluid to high-speed centrifugation so as to remove mitochondria and microsomes.

Table 3. Incorporation of (4-^{3}H) Thymidine into Deoxyribonucleic Acid by Particle-free Extracts of Disrupted Rabbit Tissues and Chick Embryos

Incubation conditions were as in Table 1 except that the (4-^{3}H) thymidine concentration was 5 μc./ml. and T-H was 8

Tissue	Specific activity of deoxyribonucleic acid (counts/min./μmole deoxyribonucleic acid-phosphorus)
Rabbit bone marrow	2,450
Rabbit appendix	886
Rabbit liver	545
Rabbit kidney	505
Chick embryo	1,865

These findings with different tissues are in accordance with the observations of Friedkin and Wood[4] with tissue slices incorporating ^{14}C-thymidine and with our own previous findings on the incorporation of ^{32}P-phosphate, ^{14}C-formate and ^{14}C-adenine in rabbit tissues *in vivo*[12].

Evidence that the material into which the tritiated thymidine is incorporated is deoxyribonucleic acid is provided by the observations that it is insoluble in acid, precipitated by acid after alkaline incubation, can be isolated as deoxyribonucleic acid which on hydrolysis yields the expected four bases of which the thymine alone is radioactive, and is broken down by deoxyribonuclease to yield acid-soluble radioactive fragments. Moreover, when the radioactive deoxyribonucleic acid is degraded by the diphenylamine method[13], radioactive thymidine-3′ : 5′-diphosphate has been isolated after ionophoresis of the reaction products, as well as other radioactive components showing the spectral and mobility characteristics which would be expected of oligonucleotides containing both thymine and cytosine.

It is impossible at this stage to determine whether the incorporation of tritiated thymidine consists merely of the addition of a terminal nucleotide (or nucleotides), or whether the thymidylic acid is to be found in the body of the polynucleotide chain (both processes are known to take place in relation to incorporation of ribonucleotides into ribonucleic acid by cell-free systems[14]); but if, as appears probable, the incorporation of ^{3}H-thymidine is due to true synthesis of deoxyribonucleic acid, it must be assumed that the remaining three nucleotides are provided from the small pool of deoxynucleosides and deoxynucleotides which is known to exist in mammalian tissues[15]. Biosynthesis would then proceed by two major steps, the phosphorylation of the nucleosides and the assembly of the phosphorylated products into the polynucleotide chain. Although the bacterial polynucleotide phosphorylase of Ochoa[16] utilizes ribonucleoside diphosphates in the formation of ribopolynucleotides, the work of Kornberg[17] with bacterial systems suggests that the deoxynucleoside triphosphates are required for synthesis of deoxyribonucleic acid. The ability of mammalian enzymes to phosphorylate deoxynucleotides has already been demonstrated with kidney mitochondria[18], rat liver homogenates[19] and bone marrow extracts[20], and our extracts of sonically disrupted ascites cells have been found capable of converting deoxyribonucleoside monophosphates to the triphosphate stage (Keir, H. M., and Smellie, R. M. S., unpublished results).

It is clear that our system is similar to the systems found in regenerating rat liver by Bollum and Potter[9] and by Mantsavinos and Canellakis[21] for the incorporation of ^{3}H-thymidine[9] or ^{14}C-deoxynucleotides[21] into deoxyribonucleic acid, although the conditions employed by these authors are rather different from ours. Both groups found that the addition of primer deoxyribonucleic acid greatly stimulated incorporation. In our system this is not essential, since the crude particle-free extract of disrupted ascites cells already contains measurable amounts of deoxyribonucleic acid and a substantial quantity of ribonucleic acid, but addition of carrier deoxyribonucleic acid greatly increases incorporation.

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PREPARATIVE-SCALE GAS CHROMATOGRAPHY

By Dr. D. E. M. EVANS, W. E. MASSINGHAM, Prof. M. STACEY, F.R.S., and Dr. J. C. TATLOW

The Chemistry Department, The University, Edgbaston, Birmingham 15

ANALYTICAL gas chromatography has been studied extensively during the past few years and is now used very widely. In this Department[1–5], gas chromatography has been applied also on a preparative scale (1–10 gm.) for the isolation of pure compounds from volatile mixtures which are difficult to separate in other ways. This aspect has apparently received little attention elsewhere, and few such developments are described in the literature[6–8]; it has been suggested, in fact, that any appreciable increase in column diameter would lead to a rapid decrease in efficiency. Consequently, small-scale batch processes have been employed for isolating specimens, using narrow-bore columns[7,9]. In view of the apparent scepticism about the value of the technique on a preparative scale, we wish to direct attention to our work on this type of gas chromatography, independently of the reporting of results in organic fluorine chemistry to which it has been applied. A process of high efficiency, capable of separating complex mixtures of volatile compounds in 1–50gm. quantities in a single cycle, is clearly of great potential importance, particularly if the apparatus is relatively simple. We have developed such equipment, which is used regularly on a routine basis by a large group of research workers.

We have already reported the design[1,2] and use[1–5] of a column having a total length of 16 ft. and an internal diameter of 30 mm., and packed with dinonyl phthalate/kieselguhr. The scaling up of the gas chromatographic process caused no apparent decrease in resolution. A similar column has been operated[4] with a packing of tricresyl phosphate/kieselguhr. We have since constructed an even bigger column, made of hard glass, packed with dinonyl phthalate/kieselguhr (1 : 2), and of the same total length (16 ft.; in two sections, each of 8 ft., joined by a narrow-bore bend) but having an internal diameter of 75 mm. It is mounted horizontally in electrical heaters of a type described before[10]. This column is being operated continuously as a general-purpose fractionating unit of high efficiency by colleagues in our fluorine research group. The cross-sectional area of this column is roughly six times that of the smaller preparative-scale unit, and for a series of separations under similar operating conditions the maximum sizes of samples have been about six times those for the smaller column. The actual quantity of any mixture which may be separated in either type of column depends chiefly on the differences in retention times between the various components present. With the larger unit, if the peaks are well apart, a charge of 50 gm., or even more, may be separated with ease. If the peaks are close, 12–15 gm. will probably represent the optimum quantity. As with all columns, an efficient pre-heater is necessary to volatilize the charge rapidly. Table 1 lists a few separations, typical of many examples with analogous compounds, which have been carried out using the larger column.

The design of the apparatus is essentially the same as that described earlier[1,2]. However, one important modification to the detector unit has been necessary. The sensitivity of katharometer detectors fell rapidly with increasing velocity of the gas. One solution to this problem would have been to use a by-pass system, passing only a small portion of the gas through the detector. However, experiments with such a system showed that in certain cases some mixing occurred in the collecting trap when two peaks which were close together were being eluted, despite the indication of a complete separation by the detector unit. It was found rather troublesome to eliminate this effect completely, and it appeared desirable to pass the total effluent from the column through the detector. Preliminary experiments, using glass katharometers of wide bore, indicated that although a normal signal could be obtained by increasing the diameter of the sensing channel to compensate for the high rates of flow of the carrier

Table 1. Separations using a Column (16 ft. × 75 mm. int. diam.) packed with Dinonyl Phthalate/Kieselguhr

Components of Mixture	Total charge (gm.)	Weight recovered (gm.)	Boiling point (°C.)	Retention time (min.) (start of peak)	Nitrogen flow-rate (l./hr.)	Temperature of column (°C.)
Perfluoro*cyclo*hexane	70·0†	27·3	52	15	50	83
Diethyl ether		30·1	34	65		
Perfluoro*cyclo*hexa-1 : 4-diene	14·4‡	1·2	57	40		
Perfluoro*cyclo*hexa-1 : 3-diene		1·9	63	70		
4*H*-Nonafluoro*cyclo*hex-1-ene		6·1	69	160	42	80
3*H*-Nonafluoro*cyclo*hex-1-ene		3·3	70	200		
1*H* : 5*H*-Hexafluoro*cyclo*hexa-1 : 4-diene	20·0§	6·2*	71	95		
1*H* : 4*H*-Hexafluoro*cyclo*hexa-1 : 4-diene			75		48	110
Pentafluorobenzene		9·5	89	215		
1*H*, 4*H*/5*H*-Heptafluoro*cyclo*hex-1-ene		2·1	103	320		
1*H* : 5*H*-Hexafluoro*cyclo*hexa-1 : 4-diene	17·0	8·7	71	225		
1*H* : 4*H*-Hexafluoro*cyclo*hexa-1 : 4-diene		5·8	75	285	50	71

* Not separated at this temperature.
† This mixture is an azeotrope used to remove perfluoro*cyclo*hexane from polyfluoro*cyclo*hexanes (ref. 3).
‡ Obtained by dehydrofluorination of 1*H* : 3*H*-decafluoro*cyclo*hexanes (refs. 1 and 4).
§ Obtained by dehydrofluorination of 1*H* : 2*H* : 4*H* : 5*H*-octafluoro*cyclo*hexanes (ref. 11).

gas used, care was necessary to avoid turbulence if the detector was to remain stable. Accordingly, a katharometer was made from a brass block by cutting in it a streamlined channel with diameter increasing gradually along its length to a maximum of approximately 1 in. and then gradually tapering down, finally terminating in a nozzle of approximately 0·25 in. diameter. In the widest part of the channel were fixed two disks of nickel gauze; between these disks (which were at right-angles to the flow of gas) was screwed an insulated metal former on which was fixed a tungsten spiral. The dead spaces between the disks and the inlet and outlet were packed with glass wool. A similar cell, in the same block, was incorporated in the gas inlet-stream, the resistances of the tungsten wires being the same. The wires form two arms of a d.c. Wheatstone bridge, powered by a 6-V. accumulator, and the out-of-balance potential was fed directly to a recorder (Honeywell-Brown, 0–1 mV.), no further amplification being necessary. A sensitivity control normally run at half the maximum was inserted before the recorder. This system is both sensitive and stable at flow-rates of gas of 50 l./hr., and minor components of the mixtures which are scarcely visible when collected in the traps may be detected with ease.

The collecting traps are of the normal design with a side inlet and central outlet. They are 60 mm. in diameter, and are cooled in liquid oxygen. It is desirable to distil the separated components from the traps *in vacuo*, since trace quantities of the packing material are progressively removed from the column in the gas stream. Recoveries of material of 80–90 per cent are obtained with ease, and if special precautions (for example, the introduction of samples *via* a vacuum line) are taken to avoid handling losses, the recoveries approach 100 per cent.

Theoretical plate determinations on each of the preparative-scale columns and on a typical analytical-scale column showed no apparent fall in efficiency with increase in column diameter. It would appear that even bigger columns could be operated successfully, particularly as more stationary phases become available. It can be seen from our results that as a practical means of separating volatile mixtures, preparative-scale gas chromatography is a remarkably successful technique. Certainly much of the recent work of our fluorine research group would have been very difficult if not impossible to carry out without it.

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INCORPORATION OF AMINO-ACIDS BY DISRUPTED STAPHYLOCOCCAL CELLS

By Dr. E. F. GALE, F.R.S., Dr. C. J. SHEPHERD and JOAN P. FOLKES

Medical Research Council Unit for Chemical Microbiology, Department of Biochemistry, University of Cambridge

IN 1953, Gale and Folkes[1] described a preparation of disrupted cells of *Staphylococcus aureus* which, in the presence of adenosine triphosphate and an energy generating source, was able to incorporate amino-acids into the trichloracetic acid precipitable fraction. Subsequent experiments[2] showed that the course of incorporation of glutamic acid labelled with carbon-14 into this fraction varied with the conditions of incubation. Two conditions in particular were studied: condition 1, in which glutamic acid was the only amino-acid added to the medium; and condition 2, in which a mixture of eighteen amino-acids was added, glutamic acid only being labelled. Under condition 2 the incorporation of glutamic acid continued at a steady rate for several hours and an increase in 'protein'-nitrogen and certain enzymic activities could be demonstrated. Under condition 1 no significant change in the 'protein' content of the preparation could be measured and the rate of incorporation, initially faster than that under condition 2, decreased rapidly so that incorporation ceased after approximately 60 min. If the disrupted cells were washed free from medium after incorporation under condition 1 had ceased, and then re-incubated in the presence of an energy source and unlabelled glutamic acid, a partial release of the incorporated radioactivity occurred; this release did not take place if the second incubation was carried out in the presence of energy source alone, unlabelled glutamic acid alone, or energy source together with unlabelled glycine or aspartic acid. It was suggested that incorporation under condition 1 could not be taken as a measure of protein synthesis, but that the results were consistent with the hypothesis that the process involved one amino-acid and arose from substitution of corresponding residues in preformed protein by an exchange reaction. Since incorporation under condition 1 could be markedly decreased by removing nucleic acid from the cell preparation, it was further suggested that such exchange reactions involved nucleoprotein complexes.

The trichloracetic acid precipitate obtained from intact or disrupted staphylococcal cells includes cell walls, and it is now known that these walls contain a hexosamine peptide polymer in which glycine, D- and L-alanine, L-lysine and D-glutamic acid are the principal amino-acids[3,4]. The recent demonstrations

Table 1. INCORPORATION OF AMINO-ACIDS INTO THE CELL-WALL FRACTION AND INTO MATERIAL FROM *Staphylococcus aureus* (STRAIN DUNCAN) INSOLUBLE IN HOT TRICHLORACETIC ACID IN INTACT AND DISRUPTED CELL PREPARATIONS

Amino-acid	Specific activity (counts/min./mμmole)	Incorporation in intact cells*		Incorporation in disrupted cells†	
		Counts/min. TCA ppt.	Per cent radio-activity in wal fraction	Counts/min. TCA ppt.	Per cent radio-activity in wall fraction
Glutamic acid	1,340	6,165 (12,503)‡	71 60	1,249	13
Glycine	534	5,458 (13,445)‡	91 94	1,081	40
Lysine	1,710	5,391	51	2,375	20
Alanine	431	2,882	70	371	25
Valine	1,175	2,221 (3,802)‡	13 15	1,092	9
Leucine	1,170	2,470	13	1,257	12

* Intact cells incubated at 0·5 mgm. dry weight/ml. in phosphate saline *p*H 7·0 containing 1·5 per cent (w/v) glucose and one of the above amino-acids (L-isomer, generally labelled with carbon-14) at 0·01 μmole/ml. except in cases marked ‡, where amino-acid concentration was increased ten times. Incubation for 60 min. at 37°. TCA ppt. = material from 1·0 mgm. dry weight of cells which is insoluble in hot 5 per cent trichloracetic acid; wall fraction separated by the method of Hancock and Park (ref. 6).

† Disrupted cells (ref. 2) incubated at 0·7 mgm. dry weight/ml. in phosphate–saline *p*H 6·25 containing adenosine triphosphate, hexose-diphosphate and one amino-acid as for intact cells.

that intact *Staphylococci* incubated with glucose can incorporate these amino-acids, added either singly or in simple mixtures to the medium, into cell wall structures[5,6] and that incorporation in animal and *Tetrahymena* cells involves a polyribonucleotide component with which amino-acids can combine in a reversible manner[7], make it desirable to re-assess and re-investigate the nature of 'condition 1 incorporation' in the disrupted staphylococcal cell preparation.

Incorporation into the Cell Wall Fraction

Table 1 shows the incorporation of certain amino-acids, each investigated under condition 1 as the only amino-acid added to the incubation medium, into the material insoluble in hot trichloracetic acid and the cell-wall fraction (separated by the method of Hancock and Park[6]) of intact *Staphylococcus aureus* strain Duncan and disrupted cell preparations made from it. With intact cells in the presence of glucose, more than 90 per cent of the glycine and more than 50 per cent of the lysine, alanine and glutamic acid is found in the cell-wall fraction, which may contain part of the cell membrane in addition to the true outer wall. In the disrupted cell preparation, the amounts of the 'wall amino-acids' which are incorporated relative to valine or leucine are smaller, and the proportion residing in the wall fraction markedly less than in the intact cell. It would appear that one result of exposure to supersonic vibration is reduction of the incorporation of amino-acids into the wall structure. The proportion of the incorporated glutamic acid found in the wall fraction varies with the preparation and has ranged from 8 to 35 per cent (mean 19 per cent), for ten preparations. The preparation used in Table 1 was exposed for the time necessary to obtain good depletion of nucleic acid[2]; shorter exposure results in a higher proportion of the incorporated glutamic acid appearing in the wall fraction.

Reversible Incorporation

Whereas the earlier experiments were carried out with material insoluble in trichloracetic acid, the nature of the bound glutamic acid not in the wall fraction has now been investigated by electrophoresis of extracts of the cells on starch columns as described by Pardee, Paigen and Prestidge[8]. After incorporation, the disrupted cell preparation is washed exhaustively in water and then subjected to a further 4-min. exposure to supersonic vibration to disintegrate its structure. The disintegrated material is centrifuged at 5,000 *g* for 30 min. to remove cell-wall fragments, the supernatant material inserted in the starch column and subjected to 600 V./30 cm. for 4½ hr. in 0·05 *M tris* buffer at *p*H 7·6. At the end of this period, the column is cut into 1-cm. sections and each section eluted with 5 ml. of water. The nucleic acid content of the eluates is measured by optical density at 260 mμ, the eluates dried and their radioactivity determined. The distribution of radioactivity along the starch columns varies with the conditions of incubation during incorporation.

Fig 1*A* shows that incorporation under condition 2 gives rise to a distribution of glutamic acid such that more than 60 per cent of the radioactivity lies in the slow-moving fractions (moving less than 10 cm. from the origin); if incorporation takes place under condition 1 (Fig. 1*B*), then 70–80 per cent of the radioactivity lies in fast-moving fractions (11–15 cm. from the origin) close to the nucleic acid front. Fig. 1*C* shows that there is no significant alteration in this latter distribution if the disrupted cell preparation is afterwards incubated with the energy source alone or unlabelled glutamic acid alone, but some 50 per cent of the radioactivity is released, and can be recovered from the medium, if the second incubation takes place in the presence of an energy source and unlabelled glutamic acid. No such reversal has been observed in the slow-moving fractions whether incorporation has taken place under condition 1 or 2; the eluates from these fractions have ultra-violet absorption spectra typical of nucleoproteins and their radioactivity is precipitated by 5 per cent trichloracetic acid in the cold.

The nature of the fast-moving fraction which becomes reversibly labelled when incubation takes place with L-glutamic acid under condition 1 is now being investigated. The α-carboxyl group is not attacked by ninhydrin, but 96 per cent of the glutamic acid is released by treatment with 0·01 *N* potassium hydroxide for 5 min. at 30° or *N* hydrochloric acid for 60 min. at 100°. Treatment with ribonuclease releases 30–40 per cent of the glutamic acid. Incubation with L-glutamic acid decarboxylase shows that the glutamic acid is not all in the L-form: 40–45 per cent of that released by acid hydrolysis assays as the L-isomer. 90 per cent of the radioactivity of the eluate from the fast-moving fraction is left in the aqueous phase after shaking with aqueous phenol[7]; addition of trichloracetic acid in the cold to 5 per cent final concentration precipitates less than 2 per cent of the radioactivity. From these results it would appear that the labelled fraction is complex, but the radioactivity is quantitatively eluted from 'Ecteola' cellulose[9] columns by 0·05 *M tris* buffer at *p*H 7·6. If the original incubation mixture contains unlabelled glutamic acid but adenine or uracil labelled with carbon-14, the fast-moving fraction and the eluate from 'Ecteola' cellulose become labelled.

When disrupted cell preparations are labelled with glutamic acid under condition 1, washed and then re-incubated under condition 2 in the absence of added glutamic acid, an amount of label ranging from 30 to 50 per cent of the total in the fast-moving fraction is

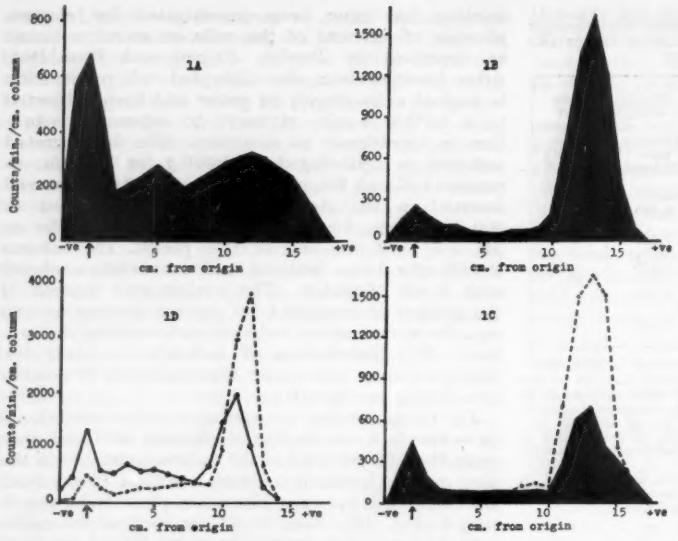

Fig. 1. Distribution, after electrophoresis on starch columns, of radioactivity in extracts from disrupted staphylococcal cells after incubation with glutamic acid labelled with carbon-14, and an energy-generating source

1*A*. Incubation under condition 2 (ref. 2) (18 amino-acids present) with 0·1 μc. glutamic acid (specific activity 0·9 mc./mmole)/ml. for 2 hr. at 37°. Total counts/min. eluted = 5,503; extract from approximately 5·5 mgm. dry-weight disrupted cells

1*B*. Incubation under condition 1 (glutamic acid being the only amino-acid added) with 0·1 μc. glutamic acid (specific activity 11·7 mc./mmole)/ml. for 1 hr. at 37°. Total counts/min. eluted = 8,329; extract from approximately 2·1 mgm. dry-weight disrupted cells

1*C*. As for 1*B*; disrupted cell preparation washed after incubation as 1*B* and re-incubated for 1 hr. in the presence of the energy-generating source alone (broken line) or with the addition of 0·4 μmole unlabelled glutamic acid/ml. (solid block). Incubation with unlabelled glutamic acid without energy-generating source gives distribution significantly the same as the broken line. Total counts eluted = 7,894 (broken line), 4,193 (solid block)

1*D*. (i) Broken line: incubation as for 1*B*; total counts/min. eluted = 11,715; extract from approximately 2·6 mgm. dry-weight disrupted cells. (ii) Continuous line: redistribution of activity in (i) obtained after preparation is washed and re-incubated for 1 hr. under condition 2 in absence of added glutamic acid; total counts/min. eluted = 11,601

Cell extracts run in all cases for 4¼ hr. in starch columns at 600 V./30 cm. in 0·05 *M tris* buffer *p*H 7·6; columns cut into 1 cm. sections, each section eluted in 5 ml. water and dried for radioactivity determinations. Abscissæ = radioactivity of eluates in counts/min. per section

transferred from that fraction to the slower-moving fractions (see Fig. 1*D*). We are at present endeavouring to investigate the relationship of the fast-moving component(s) to "soluble ribonucleic acid"[7] on one hand, and to the uridine-hexosamine-peptides that accumulate when cell-wall synthesis is inhibited by penicillin[4], on the other.

It is now clear that about 75 per cent of the bound ^{14}C-labelled glutamic acid in extracts of disrupted cells after incorporation under condition 1 is not precipitated by hot 5 per cent trichloracetic acid. The trichloracetic acid precipitate of disrupted cells contains the cell-wall fraction and the slow-moving electrophoretic fractions, whereas the bulk of the fast-moving fraction is not precipitable with trichloracetic acid. Reversible incorporation takes place in the fast-moving fraction or certain components of it; the earlier suggestion that incorporation can occur by exchange reactions involving preformed proteins is therefore no longer tenable. No explanation can be put forward at present for the occurrence of reversible incorporation in the material insoluble in hot trichloracetic acid from disrupted cells previously described, and it may be that trichloracetic acid is not a suitable reagent for investigations with preparations of this description. From the present studies it appears that the main processes occurring during incorporation of glutamic acid under condition 1 result in labelling of the fast-moving electrophoretic components and (in intact cells) incorporation into cell wall structures.

Inhibitors

One of the puzzling results obtained in the course of studies of the inhibition of amino-acid incorporation under condition 1 has been the partial or 'plateau' nature of the inhibition obtained with antibiotics such as penicillin and chloramphenicol[2,10]. It is now clear that such studies, especially when glycine is the amino-acid incorporated, involve at least two series of processes: those leading to protein synthesis, and those leading to cell-wall synthesis. Inhibitors which give a plateau type of inhibition presumably do not affect one of these series, whereas inhibitors, such as aureomycin and certain benzimidazole derivatives[10], which bring about complete suppression of incorporation, must affect both series. Chloramphenicol inhibits protein synthesis[11] but not the synthesis of cell-wall peptides[5,6]. Its action on the incorporation of glutamic acid into the nucleoprotein extracts of disrupted cells is to prevent incorporation into the slow-moving electrophoretic fractions, whereas the labelling of the fast-moving fraction is not affected. The presence of chloramphenicol during incubation thus effectively converts the distribution obtained under condition 2 (Fig. 1*A*) into that obtained under condition 1 (Fig. 1*B*) and would appear to inhibit the transfer of labelled residues from the fast-moving to the slow-moving fractions.

Incorporation Factors

The removal of nucleic acid from the disrupted cell preparation results in a decrease in its ability to incorporate amino-acids[2] and to synthesize ribonucleic acid[12]; these properties can be restored by addition to the incubation medium of staphylococcal nucleic acid. The activity of the nucleic acid preparation in restoring amino-acid incorporation is not decreased by digestion with ribonuclease but is released in fractions which were first identified as small polyribonucleotides[13]. It was later found that the activity is due to contaminating substances present in trace amounts and provisionally called "incorporation factors"[14]. A concentrate with incorporation-factor activity has now been prepared[12]; this preparation promotes the incorporation of a wide range of amino-acids, including those found in cell-wall peptides and others believed to occur in the protein only. The preparation has been routinely assayed by its ability to promote the incorporation of glycine under condition 1. Table 2 shows that the factor preparation stimulates the incorporation of glutamic acid into both protein and cell-wall fractions

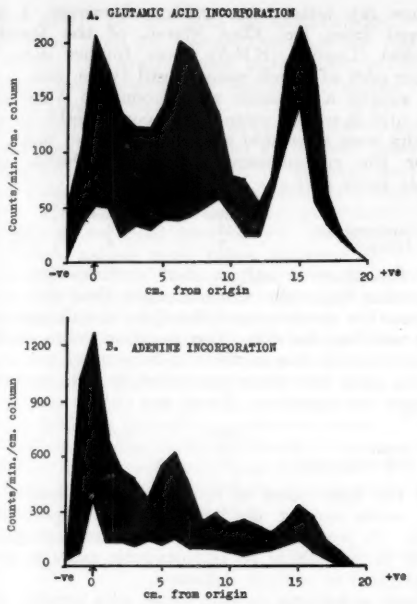

Fig. 2. Distribution of radioactivity, after electrophoresis on starch columns, in extracts of disrupted staphylococcal cells after incubation under condition 2 with (*A*) glutamic acid labelled with carbon-14, and (*B*) adenine, labelled with carbon-14, in the presence and absence of the incorporation factor preparation (ref. 12)
Procedure as for Fig. 1*A* with disrupted-cell preparation first depleted of nucleic acid by incubation with 'Streptodornase' (Lederle). Unshaded portion = incorporation in absence of incorporation factor; black portion = stimulation of incorporation by the presence of the factor preparation. Specific activity of glutamic acid in (*A*) = 0·9 mc./mmole; 103 counts/min. = 1 mμmole. Specific activity of adenine in (*B*) = 8·7 mc./mmole; dilution in course of experiment unknown

of disrupted staphylococcal cells depleted of nucleic acid.

The finding that the incorporation factor preparation is essential for ribonucleic acid synthesis[12] indicates a possible explanation for the apparent replacement of nucleic acid by the factor preparation in studies of amino-acid incorporation. Incorporation of glutamic acid is accompanied by synthesis or turnover of nucleic acid as measured by the labelling of the nucleic acid fraction, precipitable with trichloracetic acid, with adenine, guanine or uracil. Under condition 2, nucleic acid synthesis takes place at a constant rate for several hours, whereas under condition 1 the presence of labelled adenine or uracil and unlabelled glutamic acid shows that there is a limited incorporation of the bases which takes place during the first 30–60 min. of incubation only[12]. Stimulation of glutamic acid incorporation, whether under condition 1 or 2, is accompanied by a similar stimulation of adenine or uracil incorporation, and it may be that the incorporation factor preparation produces its effect on amino-acid incorporation by promoting the formation of nucleotide derivatives rather than by serving as a substitute for the nucleic acid. Fig. 2 shows the electrophoretic distribution of adenine and glutamic acid labels in extracts from disrupted cells depleted of nucleic acid, after incubation under condition 2 in the presence and absence of the incorporation factor preparation. It can be seen that the factor has stimulated incorporation of both adenine and glutamic acid into the nucleoprotein and the fast-moving fractions.

Table 2. Stimulation of the Incorporation of Glutamic Acid by the Incorporation Factor Preparation (ref. 12)

	Glutamic acid incorporated (mμ moles)/mgm. disrupted cells		
	Condition 1		Condition 2
	Wall fraction	'Protein' fraction	'Protein' fraction
Disrupted cell preparation depleted of nucleic acid	0·05	0·196	1·50
In presence of 1 mgm. staphylococcal nucleic acid/3·0 ml.	0·35	0·79	6·71
In presence of 1 unit incorporation factor preparation/3·0 ml.	0·30	0·84	7·59

Disrupted cell preparation depleted of nucleic acid by incubation with 'Streptodornase' (Lederle, ref. 12). Incubation conditions as for Fig. 1; condition 1 for 1 hr., condition 2 for 2 hr. 'Protein' fraction = material insoluble in hot 5 per cent trichloracetic acid corrected for wall fraction.

The mechanism of protein synthesis is almost certainly very complex and recent advances have revealed some of the early stages involved in the activation of amino-acids and their reaction with polyribonucleotides and nucleic acids[7]. Similar studies in bacteria are rendered more complicated by the processes leading to the formation of cell-wall peptides, and the crude fractionation procedures so far adopted have given results difficult to interpret since both types of synthesis have occurred in the fractions. The description of methods for the separation of the wall fraction[5,6] represents a welcome advance. The work described here shows that glutamic acid may be incorporated into fractions which are not precipitated by trichloracetic acid even in the cold, and suggests that the syntheses of protein and wall peptides may possess common or similar initial stages. The processes can be dissociated at later stages by the use of inhibitors such as chloramphenicol and penicillin or by treatment with supersonic vibration, although the particular stage at which dissociation occurs is not yet defined in any of these instances. Some of the earlier results[13] with intact *Staphylococcus aureus*, in which incorporation of glutamic acid was relatively unaffected although protein synthesis was inhibited, may be explained in terms of the amino-acid being channelled into wall structures, and it is now necessary to investigate the inter-relationships of wall synthesis and protein synthesis, and to determine to what extent the two processes compete for a common amino-acid under the various experimental conditions that have been studied.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Cancer and Smoking

The curious associations with lung cancer found in relation to smoking habits do not, in the minds of some of us, lend themselves easily to the simple conclusion that the products of combustion reaching the surface of the bronchus induce, though after a long interval, the development of a cancer. If, for example, it were possible to infer that smoking cigarettes is a cause of this disease, it would equally be possible to infer on exactly similar grounds that inhaling cigarette smoke was a practice of considerable prophylactic value in preventing the disease, for the practice of inhaling is rarer among patients with cancer of the lung than with others.

Such results suggest that an error has been made, of an old kind, in arguing from correlation to causation, and that the possibility should be explored that the different smoking classes, non-smokers, cigarette smokers, cigar smokers, pipe smokers, etc., have adopted their habits partly by reason of their personal temperaments and dispositions, and are not lightly to be assumed to be equivalent in their genotypic composition. Such differences in genetic make-up between these classes would naturally be associated with differences of disease incidence without the disease being causally connected with smoking. It would then seem not so paradoxical that the stronger fumes of pipes or cigars should be so much less associated with cancer than those of cigarettes, or that the practice of drawing cigarette smoke in bulk into the lung should have apparently a protective effect.

A letter of mine in *Nature*[1] included a brief first report of some data on the smoking habits of twins in Germany kindly supplied by Prof. v. Verschuer. What was evident in these data, which concerned only males, was that the smoking habits of monozygotic, or one-egg, twins were clearly more alike than those of twins derived from two eggs. The monozygotic twins are identical in genotype and the clear difference in these data gave positive *prima facie* evidence that among the many causes which may influence the smoking habit, the genotype is not unimportant.

Unfortunately, considerable propaganda is now being developed to convince the public that cigarette smoking is dangerous, and it is perhaps natural that efforts should be made to discredit evidence which suggests a different view. Assumptions are put forward which, *if true*, would show my inference from von Verschuer's data not indeed to be false but at least to be inconclusive. I may refer to an anonymous writer "Geminus" in the *New Scientist*[2], who supports in this way "what is rapidly becoming an accepted truth—that smoking can cause lung cancer".

If it could be assumed as known facts (*a*) that twins greatly influence each other's smoking habits and (*b*) that this influence is much stronger between monozygotic than between dizygotic twins, then an alternative explanation would be afforded for the result I have emphasized. The assumptions can be supported by eloquence, but they should, for scientific purposes, be supported by verifiable observations.

Since my letter was written, however, I have received from Dr. Eliot Slater, of the Maudsley Hospital (London, S.E.5), some further data, the greater part of which concern girl twins, and in this way supply a valuable supplement to Verschuer's data, and in which, moreover, a considerable number of pairs were separated at or shortly after birth.

For the resemblance in smoking habit, these female pairs give:

	Alike	Unlike	
Monozygotic	44	9	53
Dizygotic	9	9	18

So far, there is only a clear confirmation of the conclusion from the German data that the monozygotics are much more alike than the dizygotics in their smoking habits. The peculiar value of these data, however, lies in the subdivision of the monozygotic pairs into those separated at birth and those brought up together. These are:

	Alike	Unlike	
Separated	23	4	27
Not separated	21	5	26

Of the nine cases of unlike smoking habit, only four occur among the twenty-seven separated at birth. It would appear that the small proportion unlike among these 53 monozygotic pairs is not to be ascribed to mutual influence.

There is nothing to stop those who greatly desire it from believing that lung cancer is caused by smoking cigarettes. They should also believe that inhaling cigarette smoke is a protection. To believe either is, however, to run the risk of failing to recognize, and therefore failing to prevent, other and more genuine causes.

Ronald A. Fisher

Department of Genetics,
Cambridge.

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Density of Acetylene

The literature values for the density of gaseous acetylene are markedly discordant. The principal data, in order of publication, are summarized in Table 1; the values given are at $g = 980{\cdot}665$ cm./sec.[2] unless otherwise indicated.

Table 1

Author	Ref.	Density at N.T.P. (gm./l.)	Comments
Leduc	1	1·1707	
Stahrfoss	2	1·1790	Corrected to standard g
Maass and Russell	3	1·1695	
Howarth and Burt	4	1·1720	Deduced from compressibility
Sameshima	5	1·1747	Probably at standard g
Hölemann and Hasselmann	6	1·171	

In addition, International Critical Tables give a value of 1·173 gm./l. and other authorities choose one or more of the values that have been quoted. A critical survey of the literature suggested that the true value was in the neighbourhood of 1·171 gm./l., but in view of the industrial importance of acetylene it was decided to re-determine the standard density, among other properties, by the indirect method of measuring the gas imperfection with high accuracy.

Gaseous acetylene was obtained from the National Chemical Laboratory, Teddington, the co-opera-

tion of which we are glad to acknowledge. The sample used, from the 'second batch' in the description of the preparation and purification given by Ambrose[7], was transferred to the apparatus and freed from non-condensibles.

The pressure-volume product of a sample of acetylene was accurately determined at several pressures between 230 mm. and 50 mm. of mercury and the second virial coefficient deduced from the slope of PV/P. The apparatus and the procedure were essentially as reported previously[8]. Expansion and compression values were taken in runs at 0° C., 20° C. and 40° C. The acetylene came in contact with 'Pyrex' surfaces, a tungsten reference point and considerable areas of grease-free mercury. At ordinary laboratory temperatures and in normal illumination no change suggestive of decomposition occurred: in the working apparatus the product PV of a sample of acetylene at 250 mm. pressure remained constant to better than 1 in 100,000 for periods of weeks. From the PV/P lines, after making allowance for the compressibility of the reference gas (nitrogen) and all reductions to standard conditions, the second virial coefficients can be deduced as:

Temperature (° C.)	B (cm.³/mole)	
0	− 191	error ± 1 cm.³/mole
20	− 158	
40	− 133	

In the experimental range 50–230 mm. the results fit the equation

$$PV = RT + BP \text{ per mole}$$

so that the gaseous density may be expressed as $MP/(RT + BP)$ gm./l. If these relations hold up to 760 mm., then the densities of acetylene (molecular weight 26·038, R = 0·082054 litre atm./deg. C. mole) at the working temperatures are:

0° C.	1·1716,	gm./l. at 1 atmosphere
20° C.	1·0895,	
40° C.	1·0185,	(error ± 0·00005)

We regard linear extrapolation from the working range to 760 mm. as perfectly acceptable. The observed PV values fit a linear pressure relation within 1–2 parts per 100,000: if there is to be significant curvature before 760 mm. is reached some portion of this would be detectable between 50 and 230 mm. Previous work[9] over the range 190–820 mm. with carbon dioxide (T_c = 31° C.) showed that the PV/P relation was linear to within 2 in 100,000 over this pressure range at 22° C. No curvature was detected even with propane (T_c = 95·6° C.); which might be expected to show a greater effect. Indeed, there is no unambiguous direct experimental demonstration of a non-linear PV/P below 1 atmosphere for any monomeric substance. An alternative approach is to consider the form of the PV/P curve as obtained from accurate high-pressure data at a reduced temperature near that of acetylene in the present experiments, that is, T/T_c = 0·88–1·02. The isotherm of xenon at 16·65° C. (T/T_c = 1·00) over the range 20–58 atmospheres was examined by Beattie, Barriault and Brierley[10], who represent their data by an equation indicating that the PV/P relation between 0 and 1 atmosphere includes a term in P^2 which amounts to a non-linearity of 3 in 240,000. For ethane at 25° C. (T/T_c = 0·96) Beattie, Hadlock and Poffenberger[11] have examined the isotherm from 11 to 40 atmospheres: by fitting a power series equation to their results it has been shown that the curvature over 0–1 atmosphere is close to 2 in 100,000 on the PV value. It seems unlikely that acetylene should show a PV/P curvature markedly greater than these values.

Taking all the evidence for the validity of the extrapolation together, we have every confidence in the quoted densities. The differential compressibility method as a means of determining density has two advantages over direct determinations: (1) Comparative insensitivity to purity of material. Previous experience emphasizes the difficulty of removing the final traces of oxygen, nitrogen, hydrogen, inert gases and carbon dioxide from experimental gases and vapours. 0·1 per cent of either hydrogen or carbon dioxide, a significant amount if the density is determined directly, is immaterial in the virial method. (2) The only absolute determination is that of the pressure required for the pressure axis of the PV/P plot. For acetylene a precision of 0·1 mm. in 100 mm. suffices.

G. A. Bottomley
C. G. Reeves

Akers Research Laboratories,
Imperial Chemical Industries, Ltd.,
The Frythe,
Welwyn,
Herts.

G. H. F. Seiflow

General Chemicals Division,
Imperial Chemical Industries, Ltd.,
Research Department,
Widnes Laboratory,
Widnes,
Lancs.

July 9.

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Production of High Concentrations of Hydrogen Atoms

Recently we wished to produce high concentrations of hydrogen atoms in flowing gas at pressures of about 0·08 mm. of mercury. An electrodeless discharge is the most suitable source at this pressure, but although several attempts were made to use such discharges maintained by microwave radiation, a stable discharge could not be obtained at pressures less than 0·12 mm. of mercury with power inputs of up to 250 W. The discharge was therefore maintained using 9·7 Mc./s. radiation from a 350-W. radio-frequency oscillator, when the method described below proved very satisfactory. About 25 cm. downstream from the discharge, the atomic concentration was 50–60 per cent. This compares favourably with most values quoted in the literature, and using microwave radiation from a 'Raytheon' diathermy unit at 0·12 mm. mercury pressure, fewer than 10 per cent atoms were obtained. Atomic concentrations were measured with a Wrede gauge with an orifice of

0·13 mm. diameter, the differential pressure being measured directly with a sensitive differential Pirani bridge.

Discharges at this frequency spread very readily at low pressures, but this was overcome by fitting an electrostatic screen between the discharge tube and the exciting coil. The 'Pyrex' discharge tube was 12 cm. long and had an internal diameter of 3 cm. Before use, it was washed out with hydrofluoric acid and distilled water. Hydrogen entered along the axis of the tube and left at the other end through a tube joined at right angles to the discharge tube. The electrostatic screen consisted of four or five strips of copper foil 10 cm. long and ½ cm. wide laid longitudinally along the discharge tube, held at one end by asbestos string and at the other end by an earthed wire. A spiral of thin asbestos string was wound on to the tube in order to preserve a clearance of about 3 mm. between the earthed foil and the exciting coil.

The coil consisted of six turns of 8 mm. copper tubing wound so as to give a 3 mm. clearance all around the tube. A variable air-condenser was connected across the coil and adjusted to give the brightest discharge. Using damp hydrogen, the bright crimson discharge was completely contained within the discharge tube. When the earthed wire of the screen was disconnected, the discharge spread more than 1½ metres down the line.

The discharge was struck with the help of a Tesla coil, and a jet of cold air played on the tube, since this tended to collapse slightly after prolonged use. Providing no short-circuit was allowed to develop between the earthed screen and the exciting coil, this discharge tube was very satisfactory and could be used for long periods.

We wish to thank Dr. D. Roaf for suggesting the use of the screen. This work was carried out as part of Contract *AF*61(514)–1117 with the Air Research and Development Command of the United States Air Force.

K. R. Jennings
J. W. Linnett

Inorganic Chemistry Laboratory,
South Parks Road,
Oxford.
July 23.

Oxidation of Ferrous Ion in Aqueous Solution by Atomic Hydrogen

It is well known that hydrogen atoms are able to act as oxidizing agents by virtue of the high energy of formation (~ 104 kcal./mole) of the H—H bond. Thus they dehydrogenate many organic substances where C—H bond energy is only of the order of 80–90 kcal./mole.

Experimental results were obtained in aqueous solutions containing, for example, ferrous ions which were irradiated with *X*- or γ-rays[1,2] or with ultraviolet light[3,4] which led to the assumption that hydrogen atoms are formed in these systems. These atoms would then oxidize the ferrous ion to ferric. In several experiments the reaction was found to be dependent on *p*H, and Weiss[5] postulated the formation of the $H_2{}^+{}_{aq}$ ion to account for this dependence. Coulson[6] considered the stability of $H_2{}^+{}_{aq}$. Schematically the reaction may be written[7]:

$$Fe^{2+}_{aq} + (H + H^+{}_{aq}) \rightarrow Fe^{3+}_{aq} + H_2$$

To test this hypothesis we used hydrogen atoms produced by an electrodeless discharge operated at 27 Mc./s. and 0·7 kW. in hydrogen alone at 20 mm. mercury, and also in helium – hydrogen mixtures at total pressures of up to 50 mm. The hydrogen atoms thus produced were passed into the aqueous solution containing ferrous ions. Suitable blank experiments were carried out and the reducing action of the hydrogen atoms produced was measured quantitatively by reaction with silver nitrate solutions. The reduction of ferric ions in the same apparatus was also studied.

To investigate the oxidation of ferrous ions, solutions containing always 0·01 *N* ferrous sulphate and varying concentrations of sulphuric acid were treated with hydrogen atoms under constant conditions of hydrogen-pressure, discharge, rate of gas flow and duration of experiment. Qualitatively the oxidation of ferrous ion was observed and followed to 10 per cent conversion by measuring the optical density at 305 mμ. At other acid concentrations account was taken of the change in the molar extinction coefficient with simultaneous changes in *p*H and sulphate concentration. Using a lower percentage of conversion, to avoid competition with reduction of ferric ions by hydrogen atoms, the following quantitative results were obtained: with 0·7 *N* sulphuric acid, ΔFe^{3+} (m.moles/l.) = 0·54 ± 0·09. This yield remains constant to approximately *p*H 3; thus with 0·001 *N* sulphuric acid (*p*H 2·95) $\Delta Fe^{3+} = 0·50$. With 0·0005 *N* sulphuric acid (*p*H 3·30), $\Delta Fe^{3+} = 0·31 \pm 0·07$ was obtained under identical conditions, indicating that if the reaction depends on *p*H, this dependence manifests itself at or above *p*H 3 only where the ferrous–ferric system becomes unstable through hydrolysis. This supports the results of Allen[2] and is not in disagreement with the photochemical evidence of Lefort[4].

Our results show that hydrogen atoms, produced outside the aqueous system and introduced into it as such, are capable of oxidizing ferrous ions. The oxidation step may depend on *p*H. If so the reason for this may be in the mechanism involving $H_2{}^+$ ions as proposed by Weiss. Alternatively, the reaction may proceed through hydrogen abstraction from the hydration shell of the ferrous ion[7].

Gideon Czapski
Gabriel Stein

Department of Physical Chemistry,
Hebrew University,
Jerusalem.
June 30.

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Structure of Pyruvate in Aqueous Solution

In a recent publication and its addendum by Dickens and Williamson and by Bellamy and Williams[1], it was reported that the infra-red spectra of lithium pyruvate and hydroxypyruvate in the solid state show no ketonic carbonyl peak, and it was suggested that these compounds exist as the hydrate, $RCH_2C(OH)_2COO^-Li^+$, in the solid and in aqueous solution and that this hydrate may be the

substrate for the enzymatic reduction of pyruvate to lactate at neutral *p*H.

In contrast to solid lithium pyruvate, a solution of sodium pyruvate in heavy water shows a strong infra-red carbonyl absorption at 1,710 cm.$^{-1}$ (Fig. 1). A C—H bending peak at 1,358 cm.$^{-1}$, typical of a methyl ketone, as well as the strong carboxylate absorption at 1,610 and 1,410 cm.$^{-1}$, are also evident. Similar carbonyl peaks were found in deuterium oxide solutions of pyruvic acid (1,725 cm.$^{-1}$), α-ketoglutaric acid (1,722 cm.$^{-1}$) and sodium α-ketoglutarate (1,710 cm.$^{-1}$) and for sodium pyruvate in a potassium bromide pellet (1,715 cm.$^{-1}$). Furthermore, the ultraviolet absorption maximum of aqueous pyruvate[2] at 330 mμ is similar to that of α-ketoglutarate[3], oxalacetate[3], pyruvic acid[4] and ethyl pyruvate[4], and has the location and intensity expected for a carbonyl group in the alpha position to an unsaturated group[5].

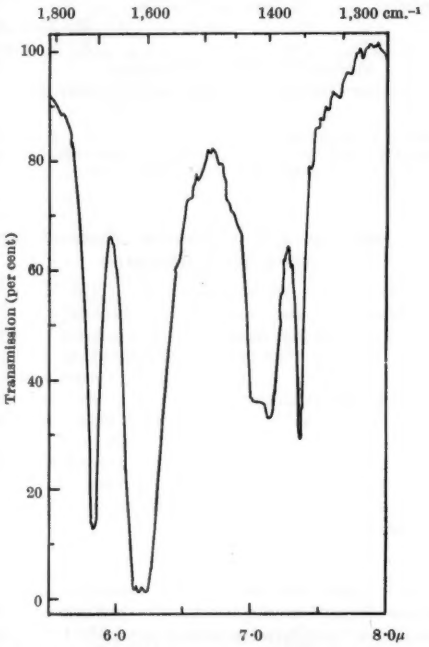

Fig. 1. Infra-red spectrum of 0·5 *M* sodium pyruvate in deuterium oxide; 0·05 mm. path-length; calcium fluoride cells; Perkin-Elmer model 21 double-beam spectrophotometer

It is concluded that pyruvate as well as pyruvic acid exist in the carbonyl form in aqueous solution, which is in accord with the low electron withdrawing ability of the negatively charged carboxylate group compared to a carboxylic acid group[6] (cf. also ref. 1) and is consistent with the chemically attractive mechanism postulated for the enzymatic reduction of pyruvate by transfer of a hydride ion from reduced diphosphopyridine nucleotide to the partially polarized, unsaturated carbonyl group[7]. The existence of solid lithium pyruvate in the hydrated form may be due to increased electron withdrawal by the concentrated positive charge of the lithium cation, or to hydration of the lithium ion by the hydroxyl groups of hydrated pyruvate in the crystal lattice, which would be favoured by the exceptionally large energy of hydration of the lithium ion.

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WILLIAM P. JENCKS
JOAN CARRIUOLO

Graduate Department of Biochemistry,
Brandeis University,
Waltham 54, Massachusetts.

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Faraday Fading of Earth Satellite Signals

THE rate of fading of Earth satellite signals caused by the ionospheric Faraday effect was used by British workers[1,2] to make estimates of the integrated electron content of the ionosphere up to the height of the satellite. The values obtained were, however, apparently too high. A possible reason for this is failure to take into account the radial velocity component of the satellite which, for certain portions of the orbit, can cause an appreciable contribution to the fading.

The complete expression for the rate of fading due to the Faraday effect is:

$$\frac{d\varphi}{dt} = 2{\cdot}36 \times 10^4 . f^{-2} . B \left\{ \frac{\partial}{\partial t} (\cos\theta \sec\delta) \int_{h_0}^{h_s} N(h) dh + (\cos\theta \sec\delta) \frac{dh_s}{dt} . N(h_s) \right\} \text{radians sec.}^{-1}$$

where f is the transmitted frequency in c./s., B the Earth's magnetic field in gauss, θ the angle between the direction of propagation and the magnetic field, δ the zenith angle, and $N(h)$ the electron density per cm.^{3}. This expression arises from the fact that h_s, the upper limit of the integral (the height of the satellite), is a function of time. The rate of fading therefore consists of two terms, one of which depends upon the integrated electron content up to the height of the satellite, and the other upon the electron density at the satellite. The second term of the equation vanishes only at perigee and apogee or for a circular orbit (and, of course, when $N(h_s)$ is zero). For the general case, however, the two terms cannot be evaluated independently from observed rates of fading. A value of $\int N dh$ computed on the assumption that the rate of fading depends only upon the first term would be too high. For the two orbits used for the estimates of $\int N dh$ referred to, the contribution of the second term apparently cannot be neglected.

A detailed discussion of these considerations will be published elsewhere.

FRED B. DANIELS
SIEGFRIED J. BAUER

U.S. Army Signal Research and
Development Laboratory,
Fort Monmouth, New Jersey.

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Neutron Activation Analysis using an Internal Standard

To correct for differences in neutron flux and neutron shadowing between sample and reference a method has been developed which uses an internal standard.

Instead of irradiating a known amount of the element as a reference, two quantities a and b of the sample are irradiated, an amount c of the element X to be determined being mixed homogeneously with b.

The material subjected to analysis should contain at least one element Y, which gives rise to an isotope measurable with good accuracy and having a half-life long in comparison with the isotope of the species analysed.

When both samples are measured at a time t, after the complete decay of the species due to X, the ratio of the activities due to Y will be given by

$$\frac{A_{t(Y)}}{A'_{t(Y)}} = \frac{a}{b} \cdot \alpha \qquad (1)$$

α being a correction factor which compensates for any difference in the neutron flux received by the two samples and/or for a different neutron shadowing.

By analysis of the decay curves, the activities $A_{\tau(X)}$ and $A'_{\tau(X)}$, due to the element X, can be computed at the end of the irradiation time τ.

The specific activity of the sample, due to X, will be given by:

$$S_{\tau(X)} = \frac{1}{c}\left[A'_{\tau(X)}\,\alpha - \frac{b}{a}\,A_{\tau(X)}\right] \qquad (2)$$

and the percentage of X present by:

$$\% X = \frac{A_{\tau(X)} \times 100}{a \times S_{\tau(X)}} \qquad (3)$$

It is also apparent that simultaneous irradiation of both samples is not required.

The method is of general use but is likely to be more important in the case of neutron sources of low intensity. In this case neutron-shadowing will be greater, as it is necessary to take large samples to reach a sufficiently high activity of the analysed element. Even when using the *BR-I* reactor, however, operating at $10^{11} n/cm.^2$ sec., neutron shadowing was observed, causing the specific activity to be low by 15 per cent when irradiating 1-gm. samples of high-alloy cobalt steel.

The method was successfully applied in the determination of vanadium and tungsten in high-alloy steels and will be described in detail elsewhere.

G. Leliaert
J. Hoste
Z. Eeckhaut

Laboratory for Analytical Chemistry,
University of Ghent.
June 23.

Error at a Rectangular Corner in Relaxation Methods

In "Relaxation Methods in Theoretical Physics" (R. V. Southwell, Clarendon Press, 1946, p. 133) results obtained by R. W. G. Gandy, using the method of relaxation, are given for the capacity C, per unit length, of a cylindrical condenser, the cross-section of which consists of concentric squares having sides in the ratio $2\sqrt{2} : 1$. Three cases are illustrated (Fig. 54): (*a*) the two squares are diamondwise to each other; (*c*) the sides are parallel; (*b*) an intermediate position.

It is with cases (*a*) and (*c*) that we are here concerned. We have calculated the value of C in these two cases from the analytical solution given by F. Bowman[1], using Milne-Thomson's "Table of Elliptic Functions".

In case (*a*) we obtain the value 6·630 for $4\pi C$, and in case (*c*) the value 6·596, as compared with Gandy's result of 6·715 in both cases.

H. Jeffreys and B. S. Jeffreys[2] give, for case (*c*) with sides in the ratio 2 : 1, results obtained analytically and by relaxation. For this ratio of sides we have computed $4\pi C$ for case (*a*) and obtain 10·660, but no corresponding result obtained by relaxation appears to be available.

These results may be of interest to those using relaxation methods, as giving some idea of the amount of error that may be expected at a rectangular corner.

R. Butler
S. V. Fagg

Department of Mathematics,
Manchester College of Science and Technology.
June 17.

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Two- and Three-Dimensional Flow of Grains through Apertures

In the course of experiments on the physics of the granular mass, the rate of discharge of three size grades of a dry, sharp sand was measured (*a*) from wide cylindrical vessels through circular and elliptical orifices, (*b*) from wide rectangular vessels through long slits. In both cases the apertures were situated on the central axis of a horizontal base. The mean particle sizes P of the size grades (18 × 36, 36 × 60, 44 × 120 British Standard mesh) were 0·053, 0·037, 0·020 cm. From the measured rate of discharge Q gm./sec., a mean linear velocity v cm./sec. was calculated as:

$$v = Q/\rho A \qquad (1)$$

A cm.^{2} being the area of the aperture and ρ the particle density in gm./cm.^{3}. To find the true linear velocity of the particles from v it would be necessary to measure the bulk density of the flowing material at the orifice; this has not been done.

The data for the three-dimensional flow systems of experiment (*a*) were found to be well correlated in a plot of the dimensionless magnitudes,

$$\varphi = \frac{v}{\sqrt{gH}} \text{ and } \left(\frac{P}{H}\right) \qquad (2)$$

where g cm./sec.^{2} is acceleration due to gravity and H is the perimetral diameter of the aperture, defined as 4 (area)/perimeter. The elliptical apertures had equal areas of 0·32 cm.^{2} and eccentricity increasing from zero to 0·995: the velocity v decreased with increasing eccentricity. Representation (2) was adequate for accounting for aperture shape. As earlier workers have shown, this representation has the advantage that φ, which depends essentially on the aperture and not the particles, does not vary much with H, Q being nearly proportional to $H^{1.5}$ for flow through circular apertures. Fowler and

Glastonbury[1] have also used the perimetral diameter for correlation of flow through apertures differing in shape.

The two-dimensional flow system of experiment (*b*) gave results which, under representation (2) (with H equal to twice the slit-width), fell on a curve distinct from that found in experiment (*a*). It can be shown that the results of experiments (*a*) and (*b*) can be reconciled by reference to the size of aperture that is just blocked by the particles.

A chain of particles having an average of about 2·7 members obstructs a slit, and a chain having about 4·3 members obstructs a circular orifice[2]. It is not unreasonable to suppose that the rate of discharge depends on the number N of chains that span an aperture, being zero for N unity. The results from experiments (*a*) and (*b*) were therefore plotted in terms of the dimensionless magnitudes,

$$\psi = \frac{v}{\sqrt{gP}} \text{ and } N \qquad (3)$$

where (in order to include the elliptical apertures)

$$N = \frac{H}{K}, \quad \begin{matrix} (K \simeq 4{\cdot}3\,P \text{ for three-dimensional flow}) \\ (K \simeq 5{\cdot}4\,P \text{ for two-dimensional flow}) \end{matrix} \qquad (4)$$

and K is the perimetral diameter of the aperture that is just blocked. The ratio of kinetic energy of a particle to the potential energy lost in falling through a particle diameter is $\frac{1}{2}\psi^2$, which is therefore a particle characteristic.

It is clear from Fig. 1 that representation (3) satisfactorily correlates the two- and three-dimensional flow systems.

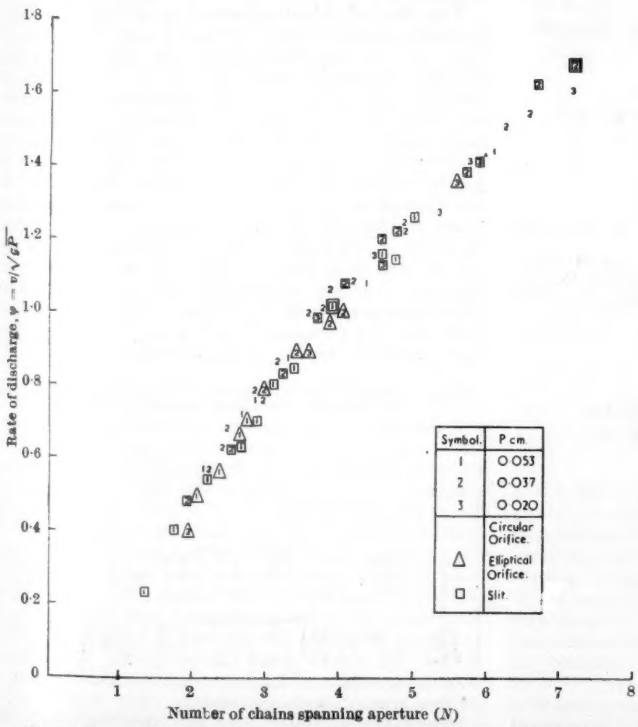

Fig. 1. Two- and three-dimensional flow of grains through apertures differing in shape and size

Further details and results for other materials and for flow from narrow vessels are given in a paper to be published elsewhere.

R. L. Brown
J. C. Richards

British Coal Utilisation Research Association,
Randalls Road,
Leatherhead, Surrey.
July 1.

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Observations of the Pacific Equatorial Undercurrent

We have succeeded in measuring the flow of the Pacific Equatorial Undercurrent first described by Cromwell, Montgomery and Stroup[1]. Taut-wire buoys[2] were anchored in 2,300 fathoms as reference points. Measurements at different depths were made by suspending a modified Roberts current meter[3] from a drifting ship. A vibrotron pressure element was used to give the depth of the meter, and the drift of the ship relative to the anchored buoy was measured by radar. To define the bottom of the undercurrent four measurements were made with Swallow type neutral buoyant floats[4]. These measurements were the principal object of the Dolphin Expedition March 27–June 10, 1958, one of the special cruises of the International Geophysical Year oceanographic programme.

Five buoys were laid on long. 140° W. at latitudes 2° N., 1° N., 0°, 1° S. and 2° S. Measurements were made from two ships, *Horizon* of the Scripps Institution of Oceanography, University of California, and *Hugh M. Smith* of the Pacific Oceanic Fisheries Investigation, U.S. Fish and Wildlife Service. The equator station was monitored by one ship during April 6–28. The second ship made measurements at the other four buoys in rotation.

On the second half the expedition *Horizon* made measurements with the Roberts meter at 180-mile intervals along the equator from long. 137° W. to 89° W. For these measurements the reference buoy was a free-floating parachute drogue[5] with the parachute suspended at 1,000 m. Parachutes at this depth were occasionally used for reference at long. 140° W. and their motion with respect to the anchored buoys was about 0·2 knots.

The Undercurrent is an east-flowing current centred at the equator just below the west-flowing South Equatorial Current. Measurements at long. 140° W. indicate a transport of the order of 30 million cubic metres a second or about the same as the transport of the Florida Current. Measurements along the current indicate that it is at least 3,500 miles long.

At long. 140° W. the Undercurrent is symmetrical about the

equator. During the 22-day observational period the highest velocities toward the east were always recorded at the equator and at a depth of 100 ± 13 m. The velocities in this core were between two and three and a half knots. During this period the South Equatorial Current was flowing westward at speeds between half a knot and one and a half knots.

The top and bottom of the Undercurrent are at about 30 and 300 m. respectively for 0°, 140° W. The Swallow drogues indicate a small flow to the west between 500 and 700 m.

The Undercurrent becomes thinner and weaker on either side of the equator. At 2° N. and S. the average thickness was 30 m. and the average maximum velocity was 0·6 knots.

Measurements made along the equator showed no diminution in the core velocity between long. 140° and 95° W. At 92° W. (25 miles west of San Isabela Island in the Galapagos) the core velocity was 1·2 knots. At 89° W. (east of the Galapagos) the Undercurrent was missing. The depth of the core rose from 100 m. at 140° W. to 52 m. at 98° W., a slope of $1{\cdot}3 \times 10^{-5}$. Stations of 95° and 92° W. showed the core dipping down. It was at 92 m. at 92° W.

Three days after the completion of these measurements, Townsend Cromwell, who discovered the Pacific Equatorial Undercurrent in 1952 and gave it its present name, was killed in an aeroplane crash near Guadalajara, Mexico, on June 2, 1958, on his way to join another Scripps Institution oceanographic expedition at Acapulco. We would like to suggest that this current be called the Cromwell Current.

John A. Knauss

Scripps Institution of Oceanography,
La Jolla, California.

Joseph E. King

Pacific Oceanic Fisheries Investigation,
Honolulu, Hawaii.
July 1.

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Protein Synthesis as a Basis for Chloramphenicol-Resistance in *Staphylococcus aureus*

It has been established that chloramphenicol is a specific inhibitor of inducible enzyme formation and of protein synthesis in general[1]. The antibiotic does not exert its effect on protein synthesis by inhibition of amino-acid activation, by inhibition of peptide bond formation, or by inhibition of incorporation of amino-acids into cell-wall[2]. Pardee, Paigen and Prestidge[3] reported that ribonucleic acid synthesized in the presence of chloramphenicol possessed an electrophoretic mobility which differed from that of normal ribonucleic acid synthesized in the absence of the antibiotic. It was later found by Neidhardt and Gros[4] that this altered ribonucleic acid was unstable and was rapidly degraded in the absence of chloramphenicol. These observations have prompted the suggestion by Gale[5] that "chloramphenicol alters, or in some way interferes with the function of the ribonucleic acid component concerned in amino-acid incorporation".

Two mechanisms of resistance to chloramphenicol have previously been observed. The enzyme 'chloramphenicol reductase' has been related to resistance of *Escherichia coli*[6] and a decreased permeability to chloramphenicol was noted by Kushner[7] in a strain of *Pseudomonas aeruginosa* which was resistant to the antibiotic.

Evidence has recently been obtained in this laboratory which indicates that a third mechanism of resistance is operative in *Staphylococcus aureus*. It has been found that both whole cells and cell-free preparations of a resistant strain are capable of forming inducible enzymes in the presence of a concentration of chloramphenicol which causes complete inhibition of the formation of enzyme in a sensitive strain.

Two strains of *Staph. aureus*, which have been described previously[8], were used throughout the study. The sensitive organism (strain *S*) was inhibited by 5 μgm. chloramphenicol per ml. and the resistant organism was capable of growing in the presence of 500 μgm. chloramphenicol per ml. The effect of chloramphenicol on formation of the two inducible enzymes, nitrate reductase and β-galactosidase, has been determined using procedures for induction and assay of the two enzymes which have been described previously[9]. The methods of Gale and Folkes[10] were used in experiments involving cells irradiated with ultrasonic waves.

The effect of chloramphenicol on induction of both enzymes in whole cells of strains *S* and *R* is shown in Table 1. In this experiment, the effect of adding 10 μgm. chloramphenicol per ml. to the system at zero time and at 2 and 4 hr. after the start of induction is compared. Addition of chloramphenicol at zero time results in a marked inhibition of the formation of enzyme in strain *S*; at 6 hr. the amount of β-galactosidase is only 12 per cent of that formed in the absence of the antibiotic. A similar inhibition is noted in the case of nitrate reductase. With strain *R*, however, addition of 10 μgm. chloramphenicol per ml. at zero time has no effect on the formation of enzyme. Another noteworthy effect is that obtained when chloramphenicol is added to the system after induction has proceeded for 2–4 hr. It is seen that this procedure results in an immediate cessation of

Table 1. Effect of Chloramphenicol (CM) on Enzyme Induction in *Staphylococcus aureus*, Strains *S* and *R*

Time*	No CM added		10 μgm. CM/ml. added at zero time		10 μgm. CM/ml. added at 2 hr.		10 μgm. CM/ml. added at 4 hr.	
	S	*R*	*S*	*R*	*S*	*R*	*S*	*R*
	β-Galactosidase							
2 hr.	0·89†	3·9	0·35	2·9	0·82	5·3	1·02	5·5
4 hr.	5·6	9·4	0·55	9·4	0·9	11·1	5·6	12·7
6 hr.	6·6	10·6	0·77	12·3	1·0	13·3	5·1	13·9
	Nitrate reductase							
2 hr.	1·48‡	2·48	0·58	6·48	0·18	6·64	0·82	8·24
4 hr.	4·0	3·82	0	3·2	0·94	4·64	4·6	7·44
6 hr.	4·8	2·8	0·34	8·1	0	5·3	2·4	7·3

* Time, in hours, after start of induction.
† μMoles of *o*-nitrophenyl-β-D-galactoside hydrolysed per mgm. cells per 30 min.
‡ μMoles of nitrite produced per mgm. cells per 30 min.

Table 2. Effect of Chloramphenicol (CM) on Induction of Nitrate Reductase in Sonicated Cells

Time (min.)	No CM	1 μgm. CM/ml.	2 μgm. CM/ml.	3 μgm. CM/ml.	4 μgm. CM/ml.
			Strain *S*		
45	0·04*	0·03	0·01	0	0
90	0·06	0·04	0	0	0
135	0·63	0·26	0·1	0·05	0·02
180	2·41	1·03	0·47	0·24	0·08
			Strain *R*		
45	0·2	0·2	0·3	0·2	0
90	0·62	0·27	0·27	0·27	0·3
135	0·66	0·16	0·49	0·69	0·6
180	1·53	1·13	1·27	1·37	1·23

* μMoles nitrite produced per mgm. sonicate per 30 min.

the formation of enzyme by strain *S*, which persists throughout the course of the experiment. On the other hand, addition of 10 μgm. chloramphenicol per ml. to strain *R* after synthesis has started does not result in inhibition.

In order to determine whether the results obtained with whole cells were due to a resistant protein-synthesis mechanism or to decreased permeability of strain *R* to chloramphenicol, an inhibition experiment was performed using cells which had been subjected to ultrasonic disintegration in a 10-kc./s. 'Raytheon' oscillator. The viable count of the suspension after sonication was 3×10^6 cells per ml. compared with 9×10^9 cells per ml. before sonication. These disrupted suspensions were fully capable of forming enzyme. It may be seen (Table 2) that, here again, strain *R* is capable of forming enzyme in the presence of a concentration of chloramphenicol which completely inhibits the formation of enzyme in strain *S*. From these results it is concluded that permeability is not the main source of resistance in this organism, but rather that some alteration has occurred in strain *R* which makes protein synthesis less susceptible to the inhibitory effect of the antibiotic. Although the nature of the altered mechanism of synthesis has not been determined, certain experiments have been performed which give some insight into the nature of the resistance. First, it has been found that growing strain *R* in the presence of chloramphenicol or pre-incubating cells in the presence of the antibiotic prior to induction does not increase subsequent resistance to it in terms of protein synthesis. It would appear, therefore, that resistance is a stable characteristic of the cells and does not depend upon the presence of the antibiotic. It has also been found that cells which have been pre-incubated in the induction medium in the presence of chloramphenicol and inducers (nitrate and galactose), and then washed and resuspended in induction medium plus inducers, do not form enzyme at a faster rate than cells which have not been pre-incubated. This would indicate that chloramphenicol exerts its inhibitory effect by interfering with normal ribonucleic acid function as suggested by Gale[5], and the ribonucleic acid formed in the presence of chloramphenicol is not available for subsequent protein formation. These results would also support those of Ben-Ishai[11], who found that preformed ribonucleic acid did not function in subsequent protein synthesis.

Two features of the results obtained should be mentioned. First, with both strains *S* and *R*, sonicated cells are more susceptible to chloramphenicol than whole cells, indicating that a permeability barrier of sorts does exist. However, this barrier is no more pronounced in strain *R* than in strain *S*, since the quantitative difference in the concentration of chloramphenicol required for inhibition of the formation of enzyme in whole cells and in sonicates is no greater in strain *R* than in strain *S*. Secondly, the concentration of chloramphenicol required to inhibit formation of enzyme is much less than that required for inhibition of growth. This dichotomy is probably due to the difference in time intervals used in induction experiments and in growth experiments. For example, in the experiments shown here six hours was the maximum time of observation. In growth experiments, particularly those involving high concentrations of chloramphenicol, the maximum time interval is often in the range of 150–200 hr. It is probable that the concentrations of chloramphenicol required to inhibit enzyme synthesis would approach that required for inhibition of growth if induction experiments could be carried out for several days. For this reason, a direct correlation between resistance in terms of growth and resistance in terms of protein synthesis, must await experiments using continuous cultivation of cells in a chemostat.

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H. H. Ramsey*

Department of Microbiology,
University of Oklahoma Medical Centre,
Oklahoma City 4, Oklahoma.
June 25.

* Present address: Research Corporation, 405 Lexington Av., New York 17.

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Permeabilizing Effects of Heparin and Heparin-like Substances

At a concentration of 0·001 per cent (w/v), heparin provokes liberation of the clearing factor from isolated perfused rabbit heart[1]. Desulphurated α-heparin and β-heparin have a similar activity, but chondroitinsulphuric acid and hyaluronic acids do not, in spite of their great chemical similarity to the three active substances[2]. Furthermore[3–5], heparin at 0·4 gm. per cent (w/v) induces an obvious diastolizing effect on a Straub preparation of isolated frog heart. Such cardiac diastolization can also be obtained by desulphurated heparin and by β-heparin at the same concentration, but not by chondroitinsulphuric acid or hyaluronic acid; only the action of β-heparin is irreversible. Diastolization is completely abolished if an over-dosage of 12 mgm. per cent of calcium ions is added to the Ringer solution.

These effects can be tentatively interpreted as an increase of permeability, at the level of cell membranes, perhaps due to removal of calcium.

In order to confirm such a hypothesis experiments have been performed on the outflow of rubidium-86 from the isolated diaphragm of albino rats.

Preliminary observations by Marro in collaboration with Hashish, made in the Zoophysiological Laboratory of Copenhagen under the direction of Prof. Ussing, seem to show a change in the outflow curve of the labelled ion, even at very low concentrations of heparin ('Eparina Novo' in ampoules).

Other experiments carried out with the same method[6,7] in our laboratories, but with 'Boots' heparin (sodium heparin 110·9 T.U./mgm.), showed the same effect, only at higher concentrations.

The samples of liquids were tested for radioactivity using a Geiger counter for liquids (type *M* 6, 20th Century Electronics).

Three groups of experiments were performed at 38° C., each on five muscles: a control group; a second group in which 70 min. after washing had started the Krebs solution was replaced by another containing heparin at a concentration of 0·05 per cent (w/v); and a third group in which, always after the same lapse of time, Krebs solution was replaced by another in which the calcium ion concentration was reduced to two-thirds of that in normal Krebs solution.

Fig. 1 shows the average results obtained from the three experimental groups, in the same order as above mentioned, from left to right; the relative counts/min. are shown on a logarithmic scale. Both the addition of heparin and the reduction of calcium ion concentration seem to modify the kinetics of exchange of rubidium-86, increasing its outflow; the modification induced by heparin appears to be quantitatively greater than that following partial removal of calcium ions.

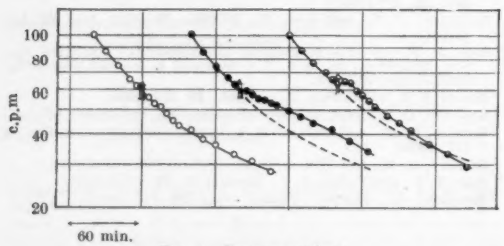

Fig. 1. For key see text.

Therefore, it seems reasonable to conclude that in rubidium exchange heparin exerts a permeabilizing action; this effect may perhaps be related to a removal of calcium ions, since it can be, at least partially, reproduced by a decrease in calcium content of the perfusing solution.

V. Capraro
F. Marro
G. Valzelli

Biological Department, C. Erba Istitute,
Milan,
and
Institute of General Physiology,
University of Parma.

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Isolation from Human Blood of a New Substance associated with Fat Transport Activity

Fat absorption was studied on a number of patients with various neoplasms. In all cases, after ingestion of iodine-131-labelled triolein dissolved in olive oil, the excretion of the labelled fat and its metabolites was followed by scintillation counting. The rate of absorption into the blood stream, and the state and distribution of the absorbed substances were investigated as follows.

The activity of aliquots of blood was measured at appropriate intervals after the injestion, and relatively larger aliquots (20 ml.) were drawn for chemical examination near the peaks of activity (2 and 4 hr.) and also after 6 hr.; at this time there was a more or less pronounced decrease in the amounts of labelled compounds in the blood. The proteins in the pooled blood (60 ml.) were precipitated with a mixture of methylal and methanol (4 : 1 to 15 vol. blood); this protein precipitant[1,2] was used in preference to the usual trichloracetic acid because it affords milder conditions of treatment (neutral reaction at room temperature).

The methylal–methanol extract contained 75–85 per cent of the whole blood activity. This includes 7–10 per cent of activity present as inorganic iodide. After evaporation to dryness *in vacuo* in the absence of oxygen, the residue was extracted with petroleum ether (60–80°), and this extract contained practically the whole activity in about 200 mgm. of fatty material. The inorganic iodide was either removed from the extract ('De-acidite F F'; Cl-form) before chromatography, or the solution was submitted without 'De-acidite' treatment to adsorption chromatography on a silica–petroleum ether column (20 mm. × 600 mm.; 80 gm. silica). The adsorbed substance was developed by gradient elution with petroleum ether – ether – methanol; the shapes of the eluent and mixing chambers were chosen in such a way as to give a linear gradient with an angle of about 40°; the start of the gradient was delayed by developing with the pure, less polar solvent until 5 × 10 ml. fractions have passed through the column.

There were two very pronounced and sharp peaks of activity in the eluted fractions: first in order of emergence, a smaller one containing about 10 per cent of the activity of the original solution, and then a second peak containing about 60 per cent of the total activity adsorbed on to the column.

The material forming the first peak has as yet not been extensively investigated; it contains, however, fatty acids and cholesterol, and is probably largely a cholesterol oleate.

The substance contained in the second peak appears to be homogeneous. After hydrolysis it contains free fatty acids, phosphate, choline, and eight to nine amino-acids: alanine, arginine, cysteine, glutamic acid, glycine, leucine, serine, threonine, and valine. However, although the one-dimensional paper chromatograms were run with markers, the results so far obtained are of a preliminary character, and work on the identification and quantitative estimation of these amino-acids is proceeding.

Solutions of the unhydrolysed substance do not contain detectable amounts of inorganic phosphate, free amino-acids, fatty acids or choline. On paper electrophoresis at *p*H 5·0 and at 8·6 the substance remains homogeneous on the origin, and no moving components could be detected on the paper in either

direction of the current. On paper chromatography in several solvent systems the substance moves as a homogeneous spot.

Quantitative determinations of choline[3], phosphorus[4], and amino-acid nitrogen[5] point to the relation 1 : 3 : nono- or deca-peptide. The substance is probably a phosphorylated pepto-lecithine-like compound; we have no indication yet where the two additional phosphoric acid residues might be.

In four of the cases examined, this substance contained the greatest amount of activity (about 60 per cent. However, in the case of one patient, this substance though present in the usual quantity, contained very little activity. In this case 59·6 per cent of the activity was contained in another fraction, which on analysis proved to contain a similar peptide, fatty acids and phosphorus but no choline. The reason for this is not clear and work is continuing in this direction.

It is interesting to speculate about the possible relation of this pepto-lecithine-like substance with the peptide of the lipid mobilizing factor described in the literature[6]. In fact, the two-dimensional amino-acid chromatograms of the hydrolysates of our substance show great similarity to those of the fat mobilizing factor found in human urine[7] (Dr. Ivor Smith, private communication).

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W. S. Reith
M. J. Thomas

Physics Department,
Barnato Joel Laboratories,
Middlesex Hospital Medical School,
London, W.1. June 30.

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Movements of Potassium in Rabbit Auricles

Movements of potassium-42 have been measured in beating right and quiescent left rabbit auricles at 37° C., immersed in modified Krebs saline containing 5·2 mM potassium, and gassed with an oxygen/carbon dioxide mixture to a pH of 7·35[1]. Efflux was measured by counting the tissue directly in a bath of 10 ml. capacity, through which flowed inactive medium, after a period of immersion in active medium[1,2]. Influx measurements were made in the same apparatus in the presence of active medium. Although the contribution of the medium to the observed counting rate was high throughout, and the total increase in count was never more than twofold, reproducible increments in tissue count were obtained for about 120 min. Retropolation to zero time of the counts between 5 and 24 min. of efflux, plotted semi-logarithmically, allowed the true bath background to be obtained, free from the effects of displacement of medium and absorption of counts by the tissue.

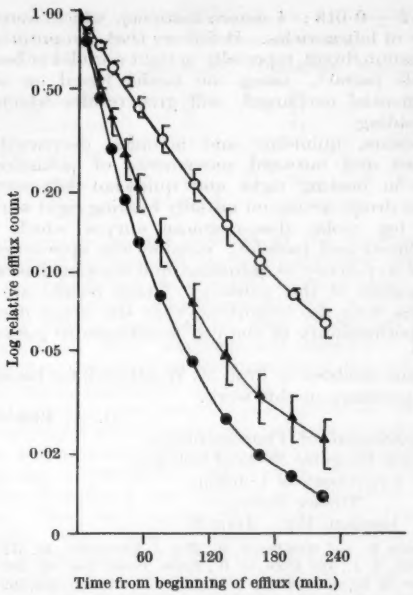

Fig. 1. Efflux of potassium-42 from rabbit auricles; ○, efflux from non-beating left auricles; ▲, efflux from right auricles beating at 170–210/min.; ●, efflux from left auricle stimulated electrically at 210/min. Range marks, standard error of three right and two left auricles. The curve of non-beating left auricles is significantly different from those of beating right auricles ($P < 0·01$), and stimulated left auricle ($P < 0·05$)

In the absence of tissue, more than 99·5 per cent of the active medium was washed out of the bath within 3 min., on changing to inactive medium. The method of measuring influx offered the advantage that influx and efflux could be followed in the same tissue, and that the tissue could be stimulated during the course of influx measurement.

Neither influx nor efflux of tracer followed a strictly exponential course. The initial influx rate-constant, k_i, was always smaller than the initial efflux rate-constant, k_e, measured after 40 min. of influx. Both values, especially in right auricles, decreased with time. The ratio of initial k_i to k_e was significantly smaller ($P < 0·01$) in right (0·723 ± 0·042; standard error of 6 determinations), than left auricles (0·892 ± 0·026; standard error of 6 determinations). Losses of potassium, which were slight (about 2 per cent/hr.), and equal for right and left auricles, do not provide a satisfactory explanation for these differences. However, the results may be due to an inhomogeneity of the auricle potassium, which is greater in right than left auricles[1]. When a left auricle was stimulated electrically to beat at the same rate as spontaneously beating right auricles (about 200 per min.), its curves of efflux (Fig. 1) and influx closely resembled those of right auricles. The difference in the shape of curves of right and left auricles appears to depend, therefore, on the activity of the tissue, and results from incomplete equilibration of the potassium which is exchanged at each beat with the rest of the cell potassium, rather than on the presence in the right auricle of special cells which exchange their potassium more rapidly. This is supported by the observation that right auricles, after treatment with some drugs in concentrations which just inhibited mechanical activity (for example, 8×10^{-5} M quinidine), had influx and efflux curves, and a ratio of initial k_i to k_e

(0·912 ± 0·018; 4 determinations), which were like those of left auricles. It follows that computation of potassium fluxes, especially in right auricles or beating auricle pairs[1,3], using the model based on single exponential exchange[2], will give results which are misleading.

Cocaine, quinidine and atropine decreased the inward and outward movements of potassium-42 both in beating right and quiescent left auricles. These drugs, acting on initially beating right auricles, had log molar dose-response curves which were rectilinear and parallel; cocaine was approximately equal in potency to quinidine, and atropine had about one-eighth of this potency. These results are consistent with the hypothesis that the drugs decrease the permeability of the cell membrane to potassium ions[4].

I am indebted to Prof. M. Weatherall for his advice and guidance in this work.

D. A. Persoff

Department of Pharmacology,
London Hospital Medical College,
University of London,
Turner Street,
London, E.1. June 2.

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Substances depressing the Phagocytic Activity of the Reticulo-Endothelial System

In previous publications[1-3] we have reported the effect of various steroids, stilbenes and aliphatic hydrocarbons on the phagocytic activity of the reticulo-endothelial system, intimating that the strongest stimulants possessed high œstrogenicity. The present communication records the relative effect on phagocytic activity of the substances which we have found to depress the reticulo-endothelial macrophages.

The experiments were carried out on 125 male white mice (*T.O.* Swiss strain) of 20–30 gm. body-weight. Five of the animals were used to assess the effect of each substance on the phagocytic activity of the reticulo-endothelial system, each animal receiving one subcutaneous injection of 0·5 mgm. of each substance daily for six days. The phagocytic activity was then measured on the eighth day by the rate of disappearance of a known amount of carbon from the circulating blood[4], the procedure being as described in a recent communication[2]. The total body phagocytic activity or phagocytic index is denoted as previously by the symbol K.

The results are shown in Table 1. The substances in Group I were administered subcutaneously in aqueous solution. For this group 25 animals were used as controls. They were given carbon only and showed an average phagocytic index or K-value of 26.

The substances in Group II were each given in 0·05 ml. of arachis oil. For this group 25 animals were used as controls. Each received one subcutaneous injection of 0·05 ml. arachis oil daily for six days, then carbon on the eighth day. These animals showed an average phagocytic index or K-value of 13.

Compared with the control values, the results show that cortisone acetate, prednisone, prednisolone and 4-hydroxytetraphenylmethane are strong depressants of phagocytic activity, whereas the other substances shown in Table 1 are mildly depressant. None of the substances used possesses high œstrogenic activity.

Table 1. Substances which depress the Phagocytic Activity of the Reticulo-Endothelial System

	Substance administered	Phagocytic index (K value)
Group I		
Administered in aqueous solution, subcutaneously	Cortisone	7
	Prednisone	8
	Prednisolone	8
Control values for 25 untreated animals		26
Group II		
Administered in arachis oil, subcutaneously	4-Hydroxytetraphenylmethane	8
	Sitosterol	10
	Androstalone	10
	Deoxycortone acetate	10
	Ergosterol	10
	1-*p*-Hydroxyphenyl-1 : 1-diphenyl propane	10
	Lanosterol	11
	Cholesterol	11
	Stilbene	11
	4 : 4′-Dihydroxydibenzyl	11
	4 : 4′-Dihydroxystilbene	11
	3-(*p*-Hydroxyphenyl)-3-phenyl-*n*-pentane	11
Control values for 25 animals which received 0·05 ml. arachis oil subcutaneously once daily for 6 days		13

We are indebted to Sir Charles Dodds for generously supplying the majority of these substances.

We also gratefully acknowledge assistance from the Central Research Fund of the University of London.

T. Nicol
D. L. J. Bilbey

Department of Anatomy,
King's College,
London, W.C.2. July 8.

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Stomoxys sp. on Cattle in Uganda

It is common practice in Uganda to house cattle during the hottest part of the day, between 11 a.m. and 3 p.m. (approximately 10 a.m. to 2 p.m. sun time), primarily to protect them from irritation caused by the biting fly *Stomoxys* sp. Although no factual evidence is available, it is generally assumed that where cattle are left out continuously much of the observed loss of condition can be ascribed to this annoyance. Were this housing unnecessary it might be possible to avoid, not only the added expense, but also the inconvenience caused by extra herding on extensive ranching systems.

The predominant species at the Cotton Research Station, Namulonge, is *S. nigra* Macq. and, from numbers of adults recorded on tethered bait cattle, a diurnal cycle of activity is apparent (see Table 1), with minimum activity occurring between 11 a.m. and 2 p.m.

Regression analyses on the number of feeding adult flies on observed climatic factors indicate that saturation deficit accounts for the greatest part of the total variation of *Stomoxys* populations (R^2 =

Table 1. Mean Number of *Stomoxys* recorded on Two Bait Cows on 15 Occasions Between 17.3.58 and 5.5.58

Local time	a.m. 7	8	9	10	11	12	p.m. 1	2	3	4	5	6
No. *Stomoxys*	12·1	19·5	18·9	16·7	14·5	13·1	14·4	15·3	18·7	19·2	17·2	18·7

−0·435). Successive generations follow a 20–30-day interval with increased emergence preceding periods of abundant rainfall during the larval period. This confirms other work on optimum breeding conditions[1].

Adult *Stomoxys* are readily caught in modified tsetse fly traps[2] when placed up to 10 yards from cattle. The efficiency of these traps decreases as the distance increases so that at 30 yards very few flies are trapped.

The grazing habits of cattle do not appear to be seriously restricted during the periods of greatest activity of the flies since at these periods grazing activity is also near maximum (see Table 2).

Table 2. Mean Percentage of Cattle Grazing between Dawn and Dusk during Months April and May 1958

Local time	a.m. 7	8	9	10	11	12	p.m. 1	2	3	4	5	6	7
Percentage grazing	19	66	60	38	18	48	18	50	34	40	66	79	96

After three months of observation on two herds of young bullocks, one herd which is housed during the period mentioned shows a slight increase in live-weight gain over the herd left out continuously. The increase, however, is certainly not commensurate with the inconvenience and additional effort required for midday housing.

This investigation is being continued and in due course will be published elsewhere.

T. H. Coaker
R. G. Passmore

Cotton Research Station,
Empire Cotton Growing Corporation,
Namulonge, Uganda. June 13.

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Intracellular Particles of Locust Fat Body

The enzyme activities of insect mitochondrial preparations have been described in a number of papers[1–3]. I have observed that certain particle-bound enzymes in homogenates of the fat body of the desert locust (*Schistocerca gregaria* Forsk.) can be separated partially by differential centrifuging, and conclude that there are (at least) two distinct types of particles which resemble mammalian liver mitochondria and microsomes.

The tissue was taken from fifth instar nymphs on the fifth or sixth day of the eight-day stadium, freed of air sacs, washed once in cold water, drained on filter paper, and homogenized in 0·25 *M* sucrose solution at about 150 mgm. wet weight/ml.

The homogenate was centrifuged for 2 min. at about 600*g*, the upper layer of fat removed by suction, and the supernatant whole suspension decanted from the sediment of debris (and probably nuclei). The mitochondria were then sedimented from this suspension at 0° C. by spinning for 5 min. at 4,500*g*, and the supernatant carefully withdrawn and centrifuged at 14,000*g* for a further 30 min. at 0° C. The resulting clear supernatant was removed from the packed microsomes, and both particle fractions resuspended, without washing, in 0·25 *M* sucrose to the original volume of the whole suspension.

The whole suspension and the three fractions were tested for the following enzymes: (*a*) cytochrome oxidase (ref. 4, 2, 735); (*b*) fumarase (ref. 4, 1, 730); (*c*) Schradan-oxidizing enzyme, by rate of inhibition of endogenous phenyl esterase in the presence of supernatant or reduced triphosphopyridine nucleotide[5]; (*d*) aconitase, with citrate substrate (ref. 4, 1, 695); (*e*) isocitric dehydrogenase (ref. 4, 1, 699); and (*f*) phenyl esterase, by rate of liberation of *p*-nitrophenol from *p*-nitrophenyl acetate[6]. The results are expressed as percentages of the activity of the whole suspension in Table 1.

Table 1

Enzyme	Percentage activities		
	Mitochondria	Microsomes	Supernatant
Cytochrome oxidase	80	20	0
Fumarase	79	21	0
Schradan oxidizing	16	84	0
Aconitase	0	0	100
Isocitric dehydrogenase	0	0	100
Phenyl esterase	42	38	20

The mitochondrial fraction (sedimented at 4,500*g*) also contained some heavier particles which had none of the enzyme activities tested, but were distinguished by giving a red-brown colour with iodine and a positive Benedict's test only after incubation with saliva. They were presumed to consist of glycogen granules. They could be isolated by centrifuging a whole suspension at 14,000*g* for 30 min., when the sediment consisted of two clearly defined layers. The upper brown layer (mitochondria and microsomes) could be separated readily from the lower translucent grey one (glycogen-like material) by gently stirring with a small quantity of sucrose solution and decanting.

I am grateful to the Anti-Locust Research Centre for the locusts, and to Messrs. Fisons, Ltd., and the Agricultural Research Council for financial support.

M. L. Fenwick

Department of Biochemistry,
University of Leeds. June 24.

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Microvilli of the Cells of the Human Adrenal Cortex

In the course of an electron microscopic survey of the human adrenal cortex an interesting specialization of the cortical cell plasma membranes was noted. Human adrenal cortex was removed at operation, fixed in 1 per cent isotonic osmic acid, embedded in methacrylate, sectioned by the standard technique on a thermal advance microtome, and examined in a Philips *EM* 100 microscope. Using parallel thick sections stained (Wright–Giemsa) and the light microscope, the different zones and cell types were readily identified.

In many of the cells of the zona fasciculata and zona reticularis, the plasma membranes form a complex arrangement of microvilli which project into the intercellular space in contact with similar microvilli of neighbouring cells (Fig. 1). The microvilli are tubular—150–200 A. in diameter—visible as circular and longitudinal profiles, and bounded by an osmophil single membrane with, at the relatively low resolution employed, a structureless centre (Fig. 2). The prominence of the villi varies at different points on the

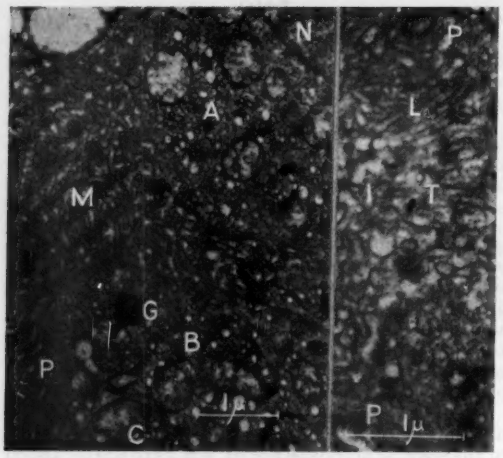

Fig. 1 Fig. 2

Fig. 1. Section through zona reticularis of human adrenal. The intercellular space between cells *A* and *B* is occupied by microvilli *M*, which are clearly evaginations of the plasma membrane *P* of the cells. *N*, Nucleus; *C*, mitochondrion; *G*, lipid globule. (× 12,000)

Fig. 2. Section through microvilli cut in longitudinal (*L*) and transverse (*T*) section. *I*, Intercellular space; *P*, cell plasma membrane. (× 18,500)

cell surface; in the wide intercellular space at the junction of three or more cells the microvilli are longer and more numerous; where two cells are closely apposed the cell membrane tends to be smooth, while adjacent to blood sinuses it is merely imbricated (Fig. 3).

The cell processes of the human adrenal cortical cells are longer and more complex than similar processes described in the rat adrenal cortex[1] and in the parathyroid[2,3], and merit the description of microvilli, that is, something more than mere interdigitating extensions of cell membranes. Such structures are generally associated with the need for an increased absorptive surface; it seems likely that in the adrenal cortex that is also their function, and that they are in some way connected with the secretion of the steroid hormones.

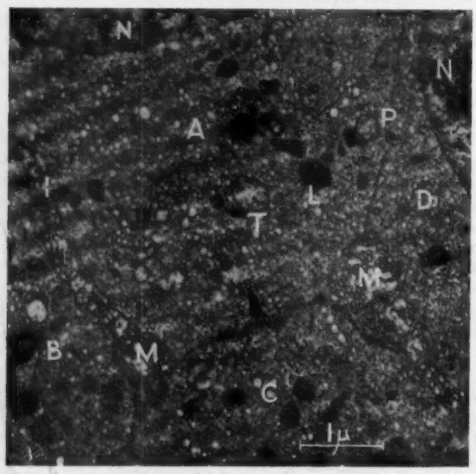

Fig. 3. Section through four cells (*A*, *B*, *C*, *D*) of zona reticularis. The plasma membranes are plane (*P*) or imbricated (*I*) where only two cells are in contiguity, but are thrown into microvilli (*M*) where the intercellular space is bigger. *N*, Nucleus; *T*, mitochondria; *L*, lipoid globules. (× 12,500)

Another characteristic of the human adrenal cortex is the clear distinction, at the electron microscopic level, between the cells of the zona reticularis and those of the zona fasciculata. The former contain relatively few lipoid granules, but larger and more numerous mitochondria as compared with those of the latter.

I. A. Carr

Department of Anatomy,
University of Glasgow.
June 20.

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Enteroviruses in the Pig

In recent years, many viruses have been recovered from the alimentary tract of man and the term 'enteroviruses' has been proposed[1] as a group name for them. The enterovirus group comprises the three strains of poliomyelitis virus, the Coxsackie viruses and the Echo (enteric cytopathogenic human orphan) viruses. The Echoviruses have not yet been conclusively associated with specific clinical conditions and it is not at present possible to determine their exact significance as causes of disease in man. Using tissue culture techniques attempts are being made in this laboratory to determine whether viruses comparable to the human enteroviruses occur in the alimentary tract of pigs.

The tissue-cultures used have been stationary monolayer cultures prepared from renal cortical tissue of the pig by a modification of Bodian's trypsinization method[2] and grown in a medium consisting of calf serum (20 per cent) and lactalbumin hydrolysate (0·5 per cent) in Hank's balanced salt solution with antibiotics. Before inoculation, the growth medium has been replaced with a maintenance medium consisting of calf serum (5 per cent) and lactalbumin hydrolysate (0·5 per cent) in Earle's balanced salt solution with antibiotics.

From the first thirteen fæces samples examined three immunologically distinct cytopathogenic agents have been recovered. One of these agents was isolated from an outbreak of a disease clinically similar to Talfan disease[3] (Teschen disease or poliomyelitis suum). This agent was neutralized by antisera to Talfan disease, kindly supplied by Mr. J. T. Done.

Another agent, one which has been studied in some detail, was recovered from fæces collected from pigs in a herd in which enteritis was a severe problem.

This virus causes a cytopathogenic effect in pig kidney cells similar to that caused by poliomyelitis in human or simian kidney cultures. The effect appears 3–5 days after inoculation but the increase in virus titre precedes this by 24 hr. Titres are of the order of 10^8 tissue-culture $ID50$ per ml. of tissue-culture fluid. The virus will pass through 'Gradocol' membranes having an average pore diameter of 100 mμ, but not through membranes with an average pore diameter of 55 mμ; preliminary electron-microscope studies show a particle of diameter of the order of 35 mμ. The agent is resistant to ether; it is inactivated within 2 min. at 56° C., within 100 hr.

at 37° C., but will survive more than three weeks at room temperature. It is easily preserved by storage at − 68° C. and can be successfully freeze-dried. Formaldehyde, at a concentration of 0·009 per cent, inactivates 90 per cent of the virus in 30–48 hr. Attempts to cause a cytopathogenic effect in bovine kidney and human epithelial cells (strain HeLa) have failed, as have attempts to adapt the virus to growth in embryonated hen's eggs.

Several attempts to infect pigs have been made with tissue-culture fluids containing virus. In all cases the experimental pigs were colostrum-deprived, 'disease-free' piglets obtained by hysterectomy following the methods of Young and Underdahl[4,5]. Various routes of inoculation were tried but the only clinical response obtained was a transient rise in temperature accompanied by a slight diarrhœa. Attempts to potentiate the response with cortisone were unsuccessful. No pathological changes were found on post-mortem examinations. The virus has been recovered from the fæces of these experimentally infected pigs, while sera from all of them showed an increase in neutralization index of more than 1,000-fold.

Studies on this virus are still in progress and will be reported in detail elsewhere.

P. H. Lamont
A. O. Betts

Department of Animal Pathology,
School of Veterinary Medicine,
University of Cambridge. June 24.

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Light and Dormancy in Wild Oats (*Avena fatua* L.)

Recently, inhibitory effects of white light on germination of wild oats with natural dormancy[1,2] and with dormancy induced by previous immersion in water[3] have been reported. To test the effect of quality of light on the germination of wild oats, white light at 440 foot-candles was provided by tungsten plus standard cool white fluorescent lamps. Infra-red filters and coloured 'Cellophane' were used to isolate the blue, red and infra-red parts of the spectrum. The temperature in each Petri dish was 24·5 ± 0·5° C.

Table 1 shows that none of the light treatments inhibited germination of non-dormant wild oats or wild oats with dormancy broken by removing the hulls and then puncturing the seed coats. However, white, blue and infra-red radiation markedly inhibited germination of partially dormant wild oats. Seeds of the lettuce var. Grand Rapids (about which much is known regarding light sensitivity[4]) were also exposed to the same conditions for comparison. Blue and infra-red radiation strongly inhibited germination of the lettuce seeds whereas red and white caused slight stimulation. Although the latter increases were small they were found consistently. Thus, red light was without effect on wild oat germination but it stimulated lettuce seed germination. White light, on the other hand, was decidedly inhibitory to wild oats but not to lettuce.

Table 1. Percentage Germination of Wild Oats and Lettuce Five Days after Inhibition, exposed to White, Blue, Red and Infra-red Radiation and Darkness. Continuous Light Source. Temperature, 24·5 ± 0·5° C.

Condition of seed sample	Quality and energy (gm. cal. cm.$^{-2}$ hr.$^{-1}$) of radiation				
	White (440 f.c.)	Blue	Red	Infra-red	Darkness
Non-dormant wild oats	97·5	100	100	100	97·5
Dormant wild oats	28·0	14·0	60·0	8·0	66·0
Dormant wild oats—dehulled then pricked	100	100	100	100	100
Lettuce var. Grand Rapids	77·0	1·5	81·0	3·0	68·5

Similar results were obtained in other tests on wild oats conducted with white light ranging from 300 to 1,500 foot-candles and at temperatures between 20 and 25° C. The response was similar under either short or long days, or continuous light.

Little attention has been given to the effect of light on the germination of weed seeds under natural conditions. To study the effect of daylight on the germination of wild oats, partially dormant and non-dormant seeds were planted on the soil surface and at a depth of 1 in. in wooden flats. One set of flats was placed in a confined space in darkness and watered frequently to maintain high humidity at the soil surface. Other flats were placed outdoors in direct sunlight; in one treatment the air above the soil surface was kept moist by an intermittent mist spray (relative humidity not less than 95 per cent), in the other the soil surface was watered at the start and then left under prevailing natural conditions (control).

Table 2 shows that there was virtually complete germination of non-dormant seeds on the surface and at a depth of 1 in., both in sunlight and in darkness. In contrast, with the partially dormant seeds in light, there was only 10 per cent germination at the soil surface, whereas 65 per cent germinated at the 1-in. depth. That the inhibitory effect on the soil surface was due to light is shown by the fact that 55 per cent germination was obtained on the surface in the dark. (The lower germination of partially dormant seed at 1 in. in darkness was afterwards found to be due to excessive watering, which was inhibitory to germination below the surface; this does not alter the conclusion that light inhibited germination at the surface).

These experiments show that, under artificial conditions, white, blue and infra-red radiation inhibit germination of partially dormant wild oats. Under natural conditions, daylight inhibits the germination of partially dormant wild oats on the soil surface; cultivations that bury such seed may therefore favour increased germination. Recent field tests have shown that, when autumn tillage was practised, wild oats

Table 2. Percentage Germination of Dormant and Non-dormant Wild Oats, planted on Soil Surface and at 1-in. Depth. Planted September 15, 1957; Data Recorded, September 23, 1957

Condition of seed sample	Depth planted	Darkness: High relative humidity*	Normal daylight: High relative humidity*	Normal daylight: Control humidity*
Non-dormant	Surface	95	98	85
	1 in.	98	100	97
Dormant	Surface	55	10	1
	1 in.	23	65	64

* High relative humidity = not less than 95 per cent.

germinated earlier and in greater numbers the following spring[5].

Bruce G. Cumming

Botany and Plant Pathology Laboratory,
Science Service,
Ottawa.

James R. Hay

Field Husbandry Division,
Experimental Farms Service,
Ottawa.

June 24.

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Effect of Gibberellic Acid on Corolla Size

In a previous communication[1] I reported that emasculation of *Glechoma hederacea* flower buds resulted in a reduction in corolla size similar to that found in naturally occurring female flowers, and I suggested that the anthers produced a hormone causing enlargement of the corolla. An attempt to replace this by the application of β-indolylacetic acid to emasculated buds was ineffective—low concentrations having no effect and high concentrations (500 and 1,000 p.p.m.) causing inhibition of corolla growth.

This year I have tested α-naphthaleneacetic acid, 2 : 3 : 5-tri-iodobenzoic acid and L-proline (cf. ref. 2), and found that they did not affect corolla size except at high concentrations, when they were inhibitory.

Dr. S. Housley suggested the use of gibberellic acid and this proved effective. When applied in aqueous solution to emasculated buds it restored the size of the corolla to that of intact flowers (the results of one experiment are given in Table 1). A small increase also resulted from treatment of intact hermaphrodite buds with gibberellic acid.

Table 1. Effect of Gibberellic Acid (10 p.p.m.) on Emasculated and Intact Hermaphrodite Flower Buds of *Glechoma hederacea*

Treatment	No. of flowers measured	Mean length of mature corollas (mm.)
Emasculated. Gibberellic acid inserted	12	19·6
Emasculated. Distilled water inserted	14	15·9
Intact. Gibberellic acid inserted	14	21·3
Intact. Distilled water inserted		19·4

Treatment of natural female flowers caused a striking enlargement of the corolla, producing flowers of about the same length as intact hermaphrodites (Table 2).

Table 2. Effect of Gibberellic Acid (10 p.p.m.) on Natural Female Flower Buds of *Glechoma hederacea*

Treatment	No. of flowers measured	Mean length of mature corollas (mm.)
Gibberellic acid inserted	12	19·1
Distilled water inserted	12	13·4

The situation appears to be comparable with that in dwarf peas, which are converted into tall peas by gibberellic acid but are unaffected by auxin alone[3].

The effect of emasculation and its reversal by gibberellic acid may be general phenomena. I have obtained results from *Geranium anemonifolium* similar to those from *Glechoma*.

Full details of the work will be published elsewhere.

Audrey Plack

Department of Biology,
University College of North Staffordshire,
Keele, Staffs.

June 26.

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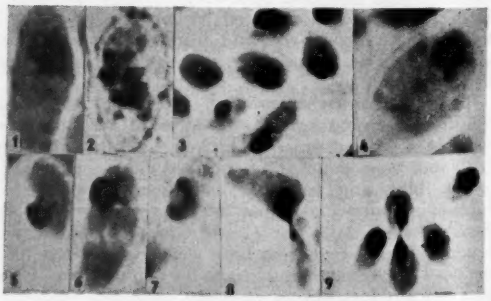
Kinetics of Mitosis in Yeasts

While differences of opinion still exist among yeast cytologists concerning the real significance of the vacuole and the chromosome number of different yeast species, it is clear from the work of De Lamater[1], Lietz[2], Winge and Roberts[3], Lindegren *et al.*[4] and McClary *et al.*[5] that (*a*) during division the yeast nucleus resolves into chromosomes which can be identified by suitable techniques; (*b*) the nuclear membrane persists throughout the division cycle, whereas in higher organisms the membrane disappears in the prophase and reforms in telophase; and (*c*) intra-nuclear mitosis is followed by a process of nuclear separation and movement into the daughter cell which simulates amitosis. Doubt whether nuclear division is amitotic[6,7] could thus arise when no distinction is made between the nuclear division proper and the transport of the daughter nucleus into the bud. We have studied the nuclear cytology of the vegetative diplophase of *Saccharomyces cerevisiae*, *Zygosaccharomyces priorianus* and *Schizosaccharomyces pombe*, using a new technique[8], and the course of mitosis and the mode of separation of daughter nuclei observed by us are described here.

Division phase. At the onset of mitosis the nucleus is resolved into chromosomes, and configurations resembling the prophase and metaphase chromosomes of other organisms could be seen in squash preparations (Figs. 1 and 2). The exact chromosome number



Figs. 1–9. Giemsa preparations of mitotic stages in *S. cerevisiae*. (1) Prophase. (2) Metaphase. (3) End of intranuclear mitosis. A double structure in some nuclei and single and divided centrosomes are seen. One cell with the smaller nucleus has apparently not yet entered mitosis. (4) A nucleus with a single centrosome. (5) and (6) Beginning of the separation of the divided halves of the nucleus. Two centrosomes are seen. (7) A near dumbbell configuration. (8) One nucleus passing into the bud. The centrosome is seen entering the bud first. (9) Final stage in the separation of nuclei

is, however, not clear. We have seen eight chromosomes (Fig. 2) in some, but not in all cells. The difficulty in getting consistent pictures of chromosomes arises largely from the persistence of the nuclear membrane. Metaphase is followed by anaphase, in which the two chromatids of each chromosome seem to go to opposite poles; telophase then sets in. We have never observed directly anaphase and telophase within the nuclear membrane, but the pattern of staining and the appearance of unstained regions within the nucleus suggest that these stages follow metaphase. It also appears that the telophase is prolonged, since nuclei appearing double are commonly seen (Fig. 3). A single centrosome is also seen at this stage (Fig. 4).

Separation phase. The centrosome divides into two at the end of the intra-nuclear mitosis. This is followed by the appearance of a small median constriction in the nuclear membrane between the centrosomes (Fig. 5). This constr.ction proceeds by furrowing and leads to a partial division of the divided nucleus. The extension of such furrowing results in the two partially divided halves of the nucleus, each provided with a centrosome, moving apart (Figs. 6 and 7). During this gradual movement, the nucleus assumes several shapes. The two centrosomes with their respective halves usually turn through 180°, resulting finally in a dumb-bell configuration. It appears that the angle of movement of the two separating halves may, however, vary—depending upon the relation between the plane of division and the position of the bud. Perfect dumb-bell configurations occur only when the angle is 180°, which happens in a majority of cases. The final separation of the daughter nuclei occurs when the nuclear membrane is stretched to the maximum. When this final separation occurs, one daughter nucleus is found in the bud and another in the mother cell (Figs. 8 and 9). If, however, the bud is far away from the plane of nuclear division or has not yet been formed, both the daughter nuclei may be found in the same mother cell. This scheme of nuclear division and separation is diagrammatically represented in Fig. 10, together with the schemes postulated by De Lamater[1], Lietz[2], and Lindegren *et al.*[4].

The method of nuclear fission and separation of daughter nuclei described above seems to be characteristic of *S. cerevisiae* in which there is apparently no synchronization in time between the appearance of the bud and any particular stage of mitosis. Neither is there any correlation between the point of origin of the bud and the plane of nuclear division. In *Schizosaccharomyces pombe*, cytokinesis is of the type seen in higher plants and the constriction in the nuclear membrane appears to start from both the ends, with the result that the different shapes of nucleus observed in *S. cerevisiae* during the separation phase are not seen. Mitosis is, however, intra-nuclear in all the yeasts studied by us.

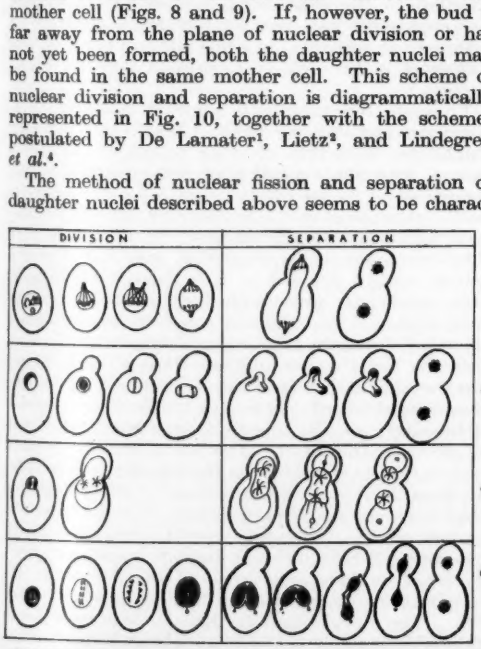


Fig. 10. Nuclear division and separation according to: *a*, De Lamater (ref. 1); *b*, Lietz (ref. 2); *c*, Lindegren *et al.* (ref. 4); *d*, the present authors.

De Lamater[1], Lietz[2], and Lindegren *et al.*[4] have used the terms 'anaphase' and 'telophase' to designate stages in the separation of the daughter nuclei, thus confusing the intra-nuclear separation of the divided chromosomes with the separation of the daughter nuclei by furrowing and subsequent movement. As a consequence, their schemes will demand both some form of synchronization between budding and anaphase of mitosis, and a localization of the point of origin of the bud with the plane of nuclear division. The doubling observed in many yeast nuclei at the end of mitosis but before separation of the daughter nuclei, as well as the lack of any relationship between budding and nuclear separation either in time or in plane of movement, supports our view that anaphase and telophase are actually completed within the nuclear membrane, thus effecting the regular distribution of the divided chromosomes prior to the initiation of a process analogous to cytokinesis in the nucleus.

We are indebted to Dr. B. P. Pal and Dr. S. M. Sikka for their interest in the study. Our thanks are also due to Prof. Ö. Winge and Dr. Catherine Roberts, of the Carlsberg Laboratory, Copenhagen, for critical advice on the manuscript.

M. S. Swaminathan
A. T. Ganesan
Indian Agricultural Research Institute,
New Delhi.

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Heat as an Agent producing High Frequency of Mutations and Unstable Genes in *Escherichia coli*

Mild heating (up to 36° C.) is known to produce a small increase of the spontaneous mutation-rates in *Drosophila* and in bacteria. We have found that using special conditions it is possible to have mesophilic non-sporogenic bacteria (*Escherichia coli*) survive relatively high temperatures (60° C.); this sub-lethal treatment produces a high frequency of mutations and unstable genes.

Mutants of strain 15 (A.T.C.C. 9723) and of strain *W6* (*F*+, mutant of *K12*)[1], yielding more survivors after heating (as below), have been isolated. 24- to 30-hr. old (37°) cultures in nutrient broth were heated by totally submerging stoppered tubes in a constant-temperature bath. In another procedure

Table 1. Stable and Unstable Mutants produced by Heat

Parent strain	Treatment	Survival (per cent)	I.C.*	Mutants			
				No. of different mutants	Description	Frequency	Stability
15 (heat resistant)	2 hr. 60° in sucrose	2×10^{-2}	+	2	Thiamine⁻	10^{-3}	Stable
	4 hr. 60° in sucrose	3×10^{-4}	+	3	'Pinpoint'	10^{-2}	Stable
	2–4 hr. 55°	2×10^{-3}–5×10^{-3}	+	4	Lactose⁻, maltose⁻	4×10^{-3}–5×10^{-3}	Stable†
	4 hr. 55°	5×10^{-3}	−	5	Partial lactose⁻	10^{-1}	Stable
	4 hr. 55°	10^{-2}	+	1	Glucose⁻, lactose⁻	2×10^{-2}	Unstable
	3–4 hr. 60° in sucrose	10^{-2}–3×10^{-4}	+	6	'Pinpoint'	10^{-3}–5×10^{-3}	Unstable
	4 hr. 55°	10^{-2}	+	4	'Pinpoint'	10^{-3}	Unstable
W6 (heat resistant)	½ hr. 60° in sucrose	6×10^{-5}	+	1	Purine⁻, thiamine⁻	10^{-3}	Stable
	2 hr. 60° dried	3×10^{-4}	+	2	'Pinpoint'	2×10^{-3}	Stable
	½ hr. 60° in sucrose	6×10^{-5}	+	2	'Pinpoint'	2×10^{-3}	Unstable

* Intermediate cultivation: None (−), or 18 hr., 37° in nutrient broth (+).
† Spontaneous 'back-mutation' (mutation-rate 3×10^{-11}) to lactose⁺, maltose⁻, to lactose⁺, maltose⁺; also directly to lactose⁺, maltose⁺

the cultures were suspended in 50 per cent sucrose, incubated for 2 hr. at 30° and then heated as above. In still another procedure the cultures were centrifuged, the pellet was dried in vacuum over phosphorus pentoxide for 2 hr. and then heated as above.

The survivors (Table 1) underwent phenotypic damage, which probably includes heat denaturation of synthesizing enzymes: after 3 hr. heating at 60° (strain 15 in sucrose), the survivors, which form colonies of various sizes on nutrient agar (non-hereditary changes), are unable to grow on minimal agar. This inability is also non-hereditary ('pseudo-auxotrophs').

The surviving populations in all heating experiments were searched for mutants by streaking on nutrient agar, Endo's agar, or minimal agar containing 0·05 per cent proteose peptone, either directly after heating or after intermediate cultivation in nutrient broth. The populations contained a very high proportion of mutants (Table 1). This high proportion already makes it unlikely that the mutants were present in the original populations and merely selected by heat treatment. However, to exclude further this possibility, several mutants were mixed with the original population and tested for survival in the same heating conditions. All these mutants were less resistant to heat than the original population, which indicates that the mutants were produced by heat and not selected by it. Similarly, the selection of mutants during the intermediate cultivation was excluded by the demonstration that the mutants grew more slowly in the nutrient broth than the original population. Thus, the actual mutation-rates may be higher than those which can be calculated from the mutant frequencies in Table 1.

The mutants isolated to date (Table 1) include those that occur spontaneously or can be readily induced by previously known agents as well as those rarely obtained by other means. Repeated incidence of thiamine⁻ mutants from different parent strains may also be unusual. Of particular interest are the unstable mutants, similar to the one which has occurred in unidentified circumstances[2] or to those which can be induced by 5-bromouracil in conditions of its incorporation into deoxyribonucleic acid of the cells[3]. The unstable mutants obtained by heating were isolated after intermediate cultivation as undersized colonies on nutrient agar; they mutated to 'pinpoint' colonies with high frequencies (of the order of 2×10^{-2}–10^{-1}); some of the 'pinpoints' were stable mutants whereas others mutated again to colonies of normal size (mutant frequencies 3×10^{-2} to 7×10^{-1}); some of the latter gave stable strains whereas others mutated again to 'pinpoint' colonies. At least four 'pinpoint' strains might be partially deficient nutritional mutants (full size colonies on richer N.I.H. agar ('Difco').

As mentioned before, some of the mutants induced by heat (non-fermenters, auxotrophs) are similar to known 'segregating' ('nuclear', 'chromosomal') mutants. This suggests that the heat-induced markers (mutants) are also 'segregating' rather than 'cytoplasmic'. However, more rigorous proof was desirable. To this end, a heat-induced purine⁻, thiamine⁻ mutant of strain *W6* was crossed with strain 1177 (*F*⁻, thiamine⁻)[1]. Out of 2,000 recombinants on minimal agar containing thiamine, 11 were isolated that were purine⁻; in addition, when a thiamine⁺ mutant of 1177 was used as *F*⁻, 1 per cent of recombinants was both adenine⁻, thiamine⁻; these results clearly indicate the 'segregational' nature of this heat-induced mutant. However, it is not unlikely that in addition to the segregating mutants studied here, heat treatment can also produce the non-reversible cytoplasmic mutants or some other unknown disturbances in the orderly process of heredity transmission.

From the foregoing, it is apparent that the mutagenic and unstabilizing effect of heat is of a different magnitude than that of other microbial mutagenic agents, with the exception of 5-bromouracil in the conditions of its incorporation into deoxyribonucleic acid[3]; as in the case of 5-bromouracil, heat as a mutagenic agent has the advantages that one can be sure that it reaches deoxyribonucleic acid and that the actual changes induced by it in this substance have been studied by physico-chemical methods. It has been suggested that the first action of the mutagenic agent is to bring the gene into an unstable state; if so, then the 'unstable mutants' are those which have not lost their instability after having mutated. If the role of cellular deoxyribonucleic acid is the determination of heredity, then its unstabilization is a likely cause of gene unstabilization. The unstabilization *in vitro* of deoxyribonucleic acid having transforming activity by heat has been demonstrated[4]; the conditions used were not much more drastic than those in the present work. Individual heredity determinants of the same cell have different stabilities towards heat[5]; it is not unlikely that some of them undergo unstabilization upon prolonged heating even at 55° or 60°. The demonstration that at least one heat-induced mutant is segregating ('chromosomal' mutation) also suggests that the damaged heredity determinant may be deoxyribonucleic acid.

This investigation was supported by research grants from the National Institutes of Health, American Cancer Society and National Science Foundation. The abstract of a part of it has been presented[6].

STEPHEN ZAMENHOF
SHELDON GREER

Department of Biochemistry,
College of Physicians and Surgeons,
Columbia University,
New York 32.

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Desiccation of Eggs of the Crane Fly (*Tipula oleracea*, L.)

THE ease with which crane fly eggs lose water is of some ecological importance since the eggs are laid near the surface of the soil, among the bases of the grass stems. In this position they are likely to experience fairly wide fluctuations in humidity, at least during drought periods.

The egg is black, measures about 0·8 mm. by 0·3 mm. and has a long, thin filament attached to one end. The incubation period is six days at 21° C. The new-laid egg looks shrunken and wizened. After 5–10 min. it becomes slim and rounded. By the third day it has absorbed water and become considerably bigger.

Using the filament, eggs were suspended in dry air and observed. The first sign of collapse is a slight flattening of one side, closely followed by the appearance of a dimple. The time taken for the dimple to appear was recorded for eggs of different ages. This measurement could be important physiologically since the collapse of the shell might be expected to cause mechanical damage to the embryo.

Eggs up to 15 min. old dimple in 2–4 min. At 15 min. old the dimpling time increases sharply to between 10 and 25 min. It increases steadily thereafter and by the sixth day eggs take 1–1½ hr. to dimple.

Eggs of different ages (5 min., 1 hr., 1 day and 4 days) were then exposed to dry air for about three times the dimpling time at their respective ages. All survived. Another group of eggs, 1 hr. old, were exposed for 100 min. (five times the dimpling time) and only 35 per cent survived. Another experiment showed that eggs more than 1 day old can survive about 1 day at 75 per cent and 2–3 days at 90 per cent relative humidity.

Two interesting points emerge from these preliminary experiments. The egg can survive considerable mechanical deformation. After the first day eggs are able to stand quite severe conditions for at least 24 hr. (and humidities of less than 95 per cent, particularly in the grass mat, are likely to prevail for no longer than the daylight hours).

It seems likely, therefore, that in the field the egg runs little risk of death from desiccation except at the beginning of the embryonic period.

Full details of these and further experiments on the water relations of the crane fly egg will be published elsewhere.

ROGER LAUGHLIN

Department of Agriculture,
King's College,
Newcastle upon Tyne.
July 1.

W. H. Perkin and the Young Chair of Technical Chemistry in the Royal College of Science and Technology, Glasgow

IN evidence on technical education given before the Select Committee on Estimates on June 19, 1953, and published in its twelfth report for the session 1952–53, Dr. (now Sir) D. S. Anderson, director of the Royal Technical College, Glasgow, mentioned that Prof. W. H. Perkin, of dye fame, had been a professor there. Afterwards, in an article on the Royal Technical College, Glasgow, in the *Journal of the Royal Institute of Chemistry* in 1954, Dr. J. A. Cranston, after stating that in 1870 James Young, who was at that time president of Anderson's University, founded the chair of technical chemistry which bears his name, giving 10,000 guineas to endow what was the first chair of applied chemistry in the United Kingdom and further sums of money to provide suitable buildings and fittings, added: "The first 'Young' Professor of Technical Chemistry, 1870–71, was William H. Perkin, discoverer of mauve dye and founder of the coal-tar colour industry".

This is not mentioned in any of the obituary notices of Perkin, and accordingly I made further inquiry of Sir David Anderson when preparing a paper on Perkin and the dyestuffs industry in Britain. In consequence, Sir David and the College librarian made further search into the matter. It appears that although the chair was offered to W. H. Perkin in September 1869, Prof. Penny, the then professor of chemistry, formally protested against the nomination and appointment of an additional professor of chemistry in, or in connexion with, Anderson's University, as adversely affecting his privileges and interests. As a result, Mr. Young withdrew the grant and asked the trustees to allow him to cancel the deed of foundation, and in July 1870 agreed to a modification of the trust deed to secure harmonious working with the existing chair of chemistry. The modified deed and the donation of £10,500 were accepted by the trustees of Anderson's University at a special meeting on July 12, 1870. Perkin's name is not mentioned in connexion with the new negotiations, so either the offer was not renewed or in the meantime he had definitely declined.

For reasons of space, no reference was made to this episode in my article in *Nature* of May 5, 1956, p. 815; but since in his recent history of the chemical industry, Haber (p. 75) writes, "James Young . . . endowed the Young Chair of technical chemistry at Anderson's University, of which he was one of the most distinguished graduates, in 1870. W. H. Perkin was the first professor, from 1870 to 1875, and was succeeded by E. J. Mills", it seems desirable to place the facts on record without further delay.

R. BRIGHTMAN

Red Lodge,
Cow Lane,
Norley, Cheshire.

FORTHCOMING EVENTS

Sunday, August 31—Wednesday, September 3

British Association for the Advancement of Science (at Glasgow).—Continuation of Annual Meeting.

Sunday, August 31

At 11 a.m.—(in Glasgow Cathedral)—Religious Service. Preacher: The Reverend Dr. Nevile Davidson, Minister of Glasgow.

Monday, September 1

At 10 a.m.—Dr. T. E. Allibone, F.R.S.: "Some Aspects of Thermonuclear Power" (Presidential Address, Section A).

At 10 a.m.—Prof. L. R. Wager, F.R.S.: "Beneath the Earth's Crust" (Presidential Address, Section C).

At 10 a.m.—Dr. Iorwerth C. Peate: "The Study of Folk Lore and Its Part in the Defence of Civilization" (Presidential Address, Section H).

At 10 a.m.—Dr. E. N. Willmer: "Some Aspects of Cellular Differentiation" (Presidential Address, Section I).

At 8 p.m.—Dr. C. F. A. Pantin, F.R.S.: "Living Machinery and the Electron Microscope" (Evening Discourse).

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Senior Lecturers and Lecturers (with a degree or equivalent qualifications with suitable teaching and professional qualifications) in the Department of Mechanical Engineering, Kumasi College of Technology—Council for Overseas Colleges, 12 Lincoln's Inn Fields London, W.C.2 (September 5).

Assistant, Grade *B* (preferably with experience in industry, teaching and/or research) in General Chemistry—The Principal, Nottingham and District Technical College, Burton Street, Nottingham (September 6).

Research Assistant (with a good degree in chemistry or biochemistry, and preferably some research experience or qualification) in the Zoology Department, to investigate effects of chemical pollutants on marine organisms—The Secretary and Registrar, The University, Southampton (September 6).

Research Assistant (with a good honours degree, a knowledge of German and ability to draw maps) in the Department of Geography—The Registrar, The University, Leeds 2 (September 8).

Lecturer or Assistant Lecturer (preferably with some experience of X-ray crystallography) in Physics—The Registrar, The University, Sheffield (September 13).

Tutorial Research Student in Zoology—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey (September 15).

Research Assistant (with a good honours degree in physics and some research experience) in the Department of Physics, to take part in research which is at present concerned with X-ray diffraction, physical optics, electronics and instrumentation—The Registrar, Manchester College of Science and Technology, Manchester 1 (September 20).

Keeper (with a good honours degree and preferably with the Diploma of the Museums Association) in the Department of Botany, Manchester Museum—The Registrar, The University, Manchester (September 30).

Lecturer (Grade I or II) (with interests in entomology or physiology) in Zoology at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 30).

Senior Lecturer or Lecturer in Mathematics at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 30).

Soil Microbiologist (Mycologist) (with a good honours degree), for work on isolation and identification of possible vectors of soil-borne viruses; and an Entomologist/Virologist (with a good honours degree), for work on problems of virus transmission—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee (October 4).

Managing Director (with high level administrative experience together with a wide knowledge of the sciences and their industrial application, or proved ability to provide administrative leadership for a technological team) of the National Research Development Corporation—The Secretary, Board of Trade, Horse Guards Avenue, London, S.W.1, marking envelope "N.R.D.C. Application" (October 13).

Senior Lecturer in Mathematics at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, October 31).

Assistant Experimental Officer (with a suitable degree, G.C.E. with chemistry at advanced level, or equivalent qualifications) in the Chemistry Department, to help with research work on the composition of milk, milk products, feeding stuffs, etc.—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 58/22.

Fisheries Officer (male, with a university degree in natural science (zoology) and preferably some experience of fishery administration) in Aden, to organize and develop the domestic fisheries of the Colony and Protectorate—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/2/01.

Lecturer in Mechanical Engineering, and a Lecturer in Mining Geology at the University of Rangoon, Burma—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting Ref. E.9/TCS/234–5–8/BUR.

Livestock Improvement Officer (with a university degree in agriculture and considerable knowledge and experience of crop and animal husbandry) in Gambia, to investigate fodder resources and subsequently initiate a programme of work designed to establish a mixed farming system of agriculture—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/12/13.

Research Assistants in (*a*) Physics, and (*b*) Telecommunications—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18.

Research Officer (Biologist) (with a good honours degree in zoology, a knowledge of marine biology, particularly fishes and plankton, with preference and aptitude for work at sea) with the East African Marine Fisheries Research Organization, Zanzibar—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/194/03.

Senior Experimental Officer (at least 35 years of age, with a pass degree, H.N.C., or equivalent qualification, and familiar with high voltage laboratory techniques and pulse circuitry), to be responsible for the construction of high energy condenser banks designed to produce very heavy current gas discharges—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1963/2.

Senior Lecturer in Chemical Engineering, and a Senior Lecturer in Metallurgy at the University of Rangoon, Burma—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting Ref. E.9/TCS/236–7/BUR.

REPORTS and other PUBLICATIONS

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Harvard University: Blue Hill Meteorological Observatory, Meteorological Radar Studies. No. 7: Particle Size Distribution in Rain and Snow Inferred from Z–R Relations. By Raymond Wexler. Pp. 1+8. No. 8: A System for Recording Eight Meteorological Elements Simultaneously on Moving Film (Weatherlog). By G. K. Thompson. Pp. vii+60. No. 10: Vertical Structure of Continuous Streamer-form Precipitation. By Raymond Wexler and David Atlas. Pp. vi+38. Final Report: Study of Synoptic-dynamic Influences on the Nature of Cloud and Precipitation Echoes, October 1953–February 1958. Pp. ii+36. Meteorological Utilization of Images of the Earth's Surface Transmitted from a Satellite Vehicle. By Arnold H. Glaser. Pp. x+145. (Milton, Mass.: Harvard University, Blue Hill Meteorological Observatory, 1957 and 1958.) [147

The Carlsberg Foundation's Oceanographical Expedition Round the World, 1928–30, and Previous "Dana" Expeditions. "Dana" Report No. 44: The Marine Water-Striders of the "Dana" Expeditions (Insecta: Hemiptera). By Jon L. Herring. Pp. 14. 2 D. Kr. "Dana" Report No. 45: The Argentinoid Fish *Xenophtalmichthys danae*. By E. Bertelsen. Notes of Miripinnati (An addendum to "Dana" Report No. 42). By E. Bertelsen and N. B. Marshall. Pp. 10+1 plate. 2 D. Kr. (Copenhagen: Andr. Fred Høst & Søn, 1958.) [147

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